• SECTION 1: System Mission Overview
• SECTION 2: Subsystem Design
• SECTION 3: Prototyping/Analysis
• SECTION 4: Manufacturing Plan
• SECTION 5: Testing Plan
• SECTION 6: User Guide Compliance
• SECTION 7: Project Management Plan (PMP)
SYSTEM MISSION OVERVIEW
SEBASTIAN REGER
MISSION OVERVIEW

To collaborate with institutions to foster innovative advancements in space payload design.

MISSION OBJECTIVES:

1. Open this opportunity to as many hands as possible to foster innovative payload design
2. Attract industry interest for current or future launches
3. Provide support to academic institutions to design payloads for cutting edge research

MINIMUM SUCCESS CRITERIA:

1. One team successfully transmits data to ground via our data acquisition subsystem.
   - The SFDC payload was prepared to provide power and transmit data to ground.

COMPREHENSIVE SUCCESS CRITERIA:

1. All teams successfully receive data via local storage or Wallop’s ground station
1. **Pre-launch T-180**
   1. WVSU: Telemetry, Geiger-Muller tubes, Particle detectors, Interferometer begins
   2. WWWC: GPS/Telemetry Begins
   3. HWS: Sensors begin collecting data

2. **Launch-Stage**
   1. WVSU: Interferometer image destabilizes
   2. MU: Motors hold position
   3. HWS: Expect temperatures as low as -90°C

3. **Apogee**
   1. WVSU: Interferometer image stabilizes
   2. HWS: External Temperature Readings Continue
   3. MU: Motors move into position and take pictures
   4. WWWC: Solar Panel & Thermionic Converter Collect heat & light
   5. WVU-SRP: Capsule Launched
   6. All other systems continue

4. **Descent**
   1. WVSU: Interferometer image destabilizes
   2. All other systems continue

5. **Chute Deploy**
   Capsule chute deploys
   All other systems continue

6. **Landing**
   All systems terminate
<table>
<thead>
<tr>
<th>EVENT</th>
<th>TIME ON</th>
<th>DWELL</th>
<th>EVENT DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSE-2</td>
<td>T-180 sec</td>
<td>515 sec</td>
<td>3 minutes before launch. Start on the computer for the experiments. Off at T+335</td>
</tr>
<tr>
<td>TE-2</td>
<td>T+196.1 sec</td>
<td>118.9 sec</td>
<td>Launch Suborbital Reentry Payload at apogee. Close Spectrometer at T + 315 sec.</td>
</tr>
<tr>
<td>TE-3</td>
<td>TBD</td>
<td>TBD</td>
<td>No teams have requested another timer event line. (TBD)</td>
</tr>
</tbody>
</table>
ACTIONS SINCE PDR:
• Finalize Design of Processing Enclosure
• Order Parts and Begin Prototyping
• Near Finalized Design of External Components of Experiment (Finalized Dimensions)
• Acquired Finalized Mission Requirements (Experimental Pointing Requirements and Requested Timer Events)

CHANGES IN DESIGN SINCE PDR:
• Most Designs Maintained and Are Just More Advanced
• Processing Enclosure aligns all boards in one direction (Simpler design of overall enclosure and Backplane Board)
• Main Deck was reoriented to allow for a longer Processing Enclosure. (Opens the option for experiments to point east)

Mission requirements/objectives were not modified by any of these modifications
Plan to use Aluminum 6061 (aircraft grade aluminum) for all machined parts.
MECHANICAL DESIGN

PROCессING ENCLOSURE

WVSU GEIGER COUNTER AND SI DETECTORS

HWS TEMPERATURE PROBE

WVU SUBORBITAL REENTRY PAYLOAD

DECK LAYOUT – NADIR
PLAN TO USE ALUMINUM 6061 (AIRCRAFT GRADE ALUMINUM) FOR ALL MACHINED PARTS
MECHANICAL DESIGN

DECK LAYOUT – ISOMETRIC PROJECTIONS

PROCESSING ENCLOSURE

WVU SUBORBITAL REENTRY PAYLOAD

WVSU

WVU SPECTROMETER

MU

WVWC
**SPECIAL REQUESTS**

**HIGH VOLTAGE**
- WVSU – Expecting 500 V on their board for their Geiger Muller Tubes generated locally by tubes – conformal coated PCB

**ON-BOARD BATTERY**
- HWS – Coin cell battery used to power Real-Time Clock
- WVU-SRP – Lithium Ion Polymer Battery – 3.7 V 500 mAh
  - Latches into circuit by Timer Event Line at apogee
- PDS – Protected 18650 Lithium Ion Battery – 3.7 V 3200 mAh
  - Latches into circuit once GSE-2 is cut
<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water-tight Processing Enclosure</td>
<td>Test</td>
<td>Dunk testing will be performed once thermal/fit testing is complete &amp; the enclosure has been machined (March)</td>
</tr>
<tr>
<td>Experiments from universities across the nation must fit on the deck</td>
<td>Model</td>
<td>An up to date model is kept detailing the space requirements of each experiment</td>
</tr>
<tr>
<td>PCBs from universities across the nation must fit within the enclosure</td>
<td>Inspection</td>
<td>A template board will be sent to each university for them to evaluate the alignment of holes for the connector and edges.</td>
</tr>
<tr>
<td>DAQ must be able to accept 4 data streams at 57,600 baud</td>
<td>Test</td>
<td>4 data streams will be computer simulated and sent to the DAQ for extensive testing in early spring</td>
</tr>
</tbody>
</table>
### SPACE FLIGHT DESIGN CHALLENGE WEIGHT BUDGET

<table>
<thead>
<tr>
<th>SUBSYSTEM</th>
<th>TOTAL WEIGHT (lbf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Distribution System</td>
<td>0.331</td>
</tr>
<tr>
<td>Data Acquisition Board</td>
<td>0.441</td>
</tr>
<tr>
<td>Processing Enclosure</td>
<td>5.145</td>
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<tr>
<td>Backplane Board</td>
<td>0.22</td>
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<tr>
<td>Deck</td>
<td>3.425</td>
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<tr>
<td>HWS</td>
<td>0.13</td>
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<tr>
<td>MU</td>
<td>0.24</td>
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<tr>
<td>WVSU</td>
<td>0.44</td>
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<tr>
<td>WVU-SRP</td>
<td>2.46</td>
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<tr>
<td>WVU-PS</td>
<td>1.43</td>
</tr>
<tr>
<td>WVWC</td>
<td>0.73</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>14.992</strong></td>
</tr>
<tr>
<td><strong>Over/Under</strong></td>
<td><strong>0.999466667</strong></td>
</tr>
</tbody>
</table>
## Space Flight Design Challenge Power Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Voltage</th>
<th>Current (A)</th>
<th>Watt</th>
<th>Time (HR)</th>
<th>Max Current Draw (A)</th>
<th>Required Batt Capacity (AMP-HOURS) -- 28V</th>
</tr>
</thead>
<tbody>
<tr>
<td>HWS</td>
<td>5</td>
<td>0.7</td>
<td>3.5</td>
<td>0.15</td>
<td>0.125</td>
<td>0.01875</td>
</tr>
<tr>
<td>MU</td>
<td>5</td>
<td>0.7</td>
<td>3.5</td>
<td>0.15</td>
<td>0.125</td>
<td>0.01875</td>
</tr>
<tr>
<td>WVSU</td>
<td>5</td>
<td>0.7</td>
<td>3.5</td>
<td>0.15</td>
<td>0.125</td>
<td>0.01875</td>
</tr>
<tr>
<td>WVU-SRP</td>
<td>3.3</td>
<td>0.215</td>
<td>0.7095</td>
<td>0.15</td>
<td>0.025339286</td>
<td>0.003800893</td>
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<tr>
<td>WVU-PS</td>
<td>5</td>
<td>0.7</td>
<td>3.5</td>
<td>0.15</td>
<td>0.125</td>
<td>0.01875</td>
</tr>
<tr>
<td>WVWC</td>
<td>5</td>
<td>0.7</td>
<td>3.5</td>
<td>0.15</td>
<td>0.125</td>
<td>0.01875</td>
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<tr>
<td>Telemetry</td>
<td>3.3</td>
<td>0.75</td>
<td>2.475</td>
<td>0.15</td>
<td>0.088392857</td>
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<tr>
<td>PDS</td>
<td>28</td>
<td>0.11</td>
<td>3</td>
<td>0.15</td>
<td>0.107142857</td>
<td>0.016071429</td>
</tr>
</tbody>
</table>

| TOTAL      |         |             |      |           | 0.845875            | 0.12688125                               |
| Over/Under |         |             |      |           | 0.914459459        | 0.2537625                                |
SUBSYSTEM DESIGN
SUBSYSTEM DESIGN

• EXPERIMENTAL
  – Hobart and William Smith Colleges
  – Marshall University
  – West Virginia State University
  – West Virginia University – Suborbital Reentry Payload
  – West Virginia University – Plasma Spectrometer
  – West Virginia Wesleyan College

• SYSTEM LEVEL
  – Power Distribution System
  – Data Acquisition Board
  – Backplane Board
  – Processing Enclosure
EXPERIMENTAL OVERVIEW
HOBART & WILLIAM SMITH COLLEGES

JOSHUA ANDREWS
MISSION OVERVIEW

To measure the temperature and vibration of a payload throughout the rocket’s flight.

Benefits future payload designs with enhanced knowledge of the strain payloads withstand during flight.

MISSION OBJECTIVES:

1. Measure the temperature of the rocket throughout its total flight.
2. Measure the vibration of the rocket throughout its total flight.

MINIMUM SUCCESS CRITERIA:

1. Collect data that portrays the temperature of the rocket throughout the total flight.
2. Collect data that portrays the vibration of the rocket throughout the total flight.

COMPREHENSIVE SUCCESS:

1. Minimum success data is collected at a higher frequency
Power on GSE-1

Temperature Probe, Piezo Sensor 1, Piezo Sensor 2

Read temperature and voltage

Save temperature and voltage

Write to SD Card and DAQ Board

Send
PIEZO SENSORS

- R1: Mission objective will not be met if piezo sensor fails to record data in the range of the frequencies of the rocket's vibration
- R2: Mission objective will not be met if the piezo sensor does not function in the high temperatures that the rocket will experience during the flight
- R3: Mission objective will not be met if the mount of the piezo sensors does not hold the sensors firm throughout the flight

TEMPERATURE SENSOR

- R4: Mission objective will not be met if the temperature cannot record the high temperatures that the rocket will experience during flight
- R5: Mission objectives will not be met if the wires cannot withstand the high temperatures and melt during flight
RESULTS

• TEMPERATURE PROBE
  – The temperature probe has been interfaced with an Arduino Uno.
  – Code has been created to read what appear to be accurate temperatures from temperature probe but more testing is to follow to ensure the accuracy of the temperature probe.
  – More will be done once the exact model of temperature probe is determined to ensure its durability and reliability

• PIEZO SENSORS
  – Like the temperature probes, the piezo sensors have been interfaced with an Arduino Uno.
  – They appear to be functioning as they should, but again more testing is needed to ensure their accuracy
  – Following their testing, work will be done to determine the optimal locations to mount them in the payload while staying within the size limitations.

PLAN:

• TEMPERATURE PROBE – Will be tested by exposing the temperature probe to known temperature conditions and observing how it changes the data retrieved.

• PIEZO SENSORS – Will be tested by exposing the piezo sensors to known frequencies likely with the use of a speaker, and see how the frequencies observed compare to the frequencies the speakers created.
ANALYSIS

• Temperature Probe
  – Graph the temperature measured against the temperature set to determine the accuracy of the probe.

• Piezo Sensors
  – Graph the frequency measured against the frequency the speaker is set to to determine the accuracy of the speaker.

• This will also allow for us to also test the limits of the sensors
TESTING PLAN

MECHANICAL:
• We are well below our allocated weight budget.
• We will be under the maximum volume.
• This will be tested further when we advance with the prototyping
• We will expose the prototype to different environments to test its durability and ensure its survival during the flight

ELECTRICAL:
• Our system has relatively simple components
• With the addition of a RTC, our sampling rate can be measured more accurately, and from there we can attempt to refine the sampling rate.
• The RTC is an internally powered component.
  – This can be tested simply by observing the functionality

SOFTWARE:
• The individual components all function with their individuals codes
  – A code that runs them all together will be developed soon
• With the recent addition of the RTC, some more research will be done to ensure it functions effectively within our systems.
MARSHALL UNIVERSITY

MAYSON PINE
MISSION OVERVIEW

To use an automated target acquisition system to take pictures of target stars and assess the effectiveness of astronomy.net for target acquisition during flight.

The data is proof of concept used for future sounding rocket flights. Running this experiment on RockSat-X will allow us to establish accuracy under flight conditions.

MISSION OBJECTIVES:
1. Take Picture of stars and calculate where the camera is looking.
2. Use location data to move camera so that it is pointing at a target star
3. Take picture of target star

MINIMUM SUCCESS CRITERIA:
1. One image
2. A calculation to move the camera toward a target star
3. An image with the target star in it

COMPREHENSIVE SUCCESS CRITERIA:
1. Acquisition of additional targets
SOFTWARE DESIGN

- Language used: Python 2.7
- Third-party programs: Astrometry.net
- Pseudo code: Have two variables, one for time elapsed and one for max time allotted. We have one main function, that is a while loop that runs as long as the elapsed variable is less than the allowed variable. At first we have to take an image to help the program understand what it is looking at. Then we run the image we get through Astrometry.net and we log the data received from it. If the field from the image contains a target list star, then we calculate the distance from the center of the field to the target list star. If it does not we select the closest star and calculate that distance and we turn the servos to that degree.
R1 – If the camera is facing too low on the main deck, it would not be able to track any stars
  • Through consistent communication between the team and the system-level team, we will be able to ensure the success of the location of the camera/mount.

R2 – We could run out of time to machine the mounts for the servos
  • Begin the manufacturing plan with a larger schedule margin of error:
• The same or similar parts were prototyped on RockSat-X 2017.

• Currently working on getting a bracket prototype so we can start putting in the motors together.

• Once we receive our Pi and encoders, the electrical system can be prototyped on a solderless breadboard.
MANUFACTURING PLAN

MECHANICAL
- **TO BE MANUFACTURED:** Brackets for each servo, Mounts for encoders, Bracket for Camera, PCB
- **TO BE PURCHASED:** Motors
- Brackets are getting finalized and sent out for machining
  - Based on time will either be machined in Marshalls Machine shop or RCBI

ELECTRICAL
- Once the PCB is received, all connections must be made.
- We anticipate 1 revision
- Currently missing the motor controller, Encoders, and Nano Pi. These parts either have been ordered or will be this upcoming weekend.
SOFTWARE MANUFACTURING PLAN

• FUNCTIONS NEEDING COMPLETION:
  – Update the functions with the timed event line
  – Fix the function that fine tunes the servos
  – Change the function to a better sorting algorithm for the stars to decrease time
  – Function for turning the servos

• THE BLOCKS OF CODE WITH THE MOST DEPENDENTS (IN ORDER):
  – Block that calls the timed events
  – Block that takes an image and turns that into coordinates/degrees to turn
  – Block that turns the servos

• PLAN/SCHEDULE (AS OF 12/10/17)
  – 12/17/17: Have the camera fully functional with taking an image and telling what stars are in the image
  – 1/16/18: Be able to calculate the distances between star from the image and a target list
  – 1/31/18: Be able to fine tune the servos to the exact degree for the target star

• Schedule may change by a few weeks. Would prefer to have almost all software completed early as possible to ensure there are no bugs.
MECHANICAL
- The experiment will regularly be weighted for frequent validation of weight requirements
- There is no vibe table in house. The System-Level team is looking into a vibe table to be borrowed for the Full Mission Simulation tag-up among SFDC teams in April
- Double check dimensions after fabrication

ELECTRICAL
- As the experiment is built, testing will be made on each joint to ensure success

SOFTWARE
- Once all parts are received to be prototyped as a full system, the code will be tested while turning the servos and taking pictures with the camera

SYSTEM LEVEL
- Once all parts are received and fully functional, full-system testing can begin. While testing all components of the system together, the system will also be tested on a high altitude balloon and the planetarium dome at Marshall
MISSION OVERVIEW

To prepare for future CubeSat missions by comparing different equipment designs and testing the feasibility of a Michelson Interferometer.

MISSION OBJECTIVES:

1. Build & test a Michelson Interferometer for use in future space missions.
2. Compare different Geiger Muller tube designs to solid state radiation detectors to find the best choice for CubeSat-related missions in the future.
3. Measure flight dynamics.

MINIMUM SUCCESS CRITERIA:

1. Capture and receive one interference pattern from the Michelson Interferometer.
2. Detect Radiation with Geiger Muller tubes.
3. Acquire data describing dynamics and magnetic fields experienced during flight.

COMPREHENSIVE SUCCESS CRITERIA:

1. Geiger Counters/Particle detectors: Detect direction of radiation and see variation of radiation in Geiger counter data.
3. IMU: Acquire data describing flight dynamics and magnetic fields during whole mission.
FUNCTIONAL BLOCK DIAGRAM

- Particle detectors: PD 1, PD 2, PD 3
- Geiger counters: GC 1, GC 2, GC 3, GC 4
- Microcontroller
- IMU
- Data Output UART / SD
- Interferometer
  - Raspberry Pi
  - Camera
  - Laser
  - Beam Splitter
  - Mirror
  - Mirror

---

Yellow: Data
Red: Laser
Blue: 5V

5V
- The payload is estimated to be around 250g and measure 4”x3-1/4”x1.5”
- There will be two PCBs 4”x3-1/4” and 1.5” apart inside the enclosure
- IMU, Raspberry Pi, microcontrollers, Si detectors, and interferometer will be on PCBs in enclosure
- Four Geiger tubes will be outside the enclosure in a 4”x5”x1’’ region
ELECTRICAL DESIGN

OVERALL ELECTRICAL SCHEMATIC

GEIGER CIRCUIT SCHEMATICS
• Geiger counter logic main loop (on microcontroller):
  – If timer tripped since last Geiger voltage change:
    • Flip voltage of circuit high or low
    • Reset timer
  – Read state of Geiger tube
  – Record state data as a circular buffer in internal memory
  – If requested is pending from Raspberry Pi:
    • Transmit buffered data to Raspberry Pi
• Interferometer logic main loop (on Raspberry Pi):
  – Capture image from camera
  – Store unprocessed image in onboard SD card
  – Crop image to exclude non-capture areas
  – Use OpenCV library to identify circles in remaining image
  – Every 20ms:
    • Request data buffers from microcontrollers (Geiger circuits, IMU, Si PIN Photodiode Detectors)
    • Create data packet containing all data buffers and a pad the packet with a portion of a recent image from the camera
GEIGER COUNTERS

• Each Geiger circuit will have input voltage 5V, current <50mA
• Four Geiger tubes will be mounted outside with one inside for comparison.
• Combined weight of the subsystem will be ~100g.
• The following Geiger tubes will be tested:

- Hamamatsu D3517
- Micro Geiger
- SBM 20
- LND 713
MICHELSON INTERFEROMETER

- Major components:
  - Mirrors (2)
  - Beam splitter
  - Lens
  - Laser
  - Camera

- Components will be arranged on a 3-1/4”x4” circuit board.
- Light emitted by the laser will be split by beam splitter.
- Light will bounce back to the beam splitter.
- Beam splitter will recombine light to form the interference pattern.
- Interference pattern will be captured by the camera.
- Total mass will be around 170g.
INERTIAL MEASUREMENT UNIT (IMU)

- IMU will determine the state of the payload in terms of acceleration, rotation, and magnetic fields in order to support the other experiments.
- Adafruit Precision NXP 9-DOF Breakout Board - FXOS8700 + FXAS21002
- $\pm 2 \text{ g}/\pm 4 \text{ g}/\pm 8 \text{ g}$ adjustable acceleration range
- $\pm 1200 \mu \text{T}$ magnetic sensor range
- $\pm 250/500/1000/2000^\circ/\text{per second}$
- Zero-offset error:
  - At +/- 2000° per second: 3.125° per second
  - At +/- 250° per second: 0.3906° per second
- Weight: 2.1g
Si PIN PHOTODIODE DETECTOR

- Three detectors will be arranged so each aligns with a separate axis.
- Purpose is to find the direction from which radiation is arriving.
- Comparing levels of radiation with Geiger counters.
- Input voltage for each: 5V, < 10mA current.
- Weight: 24g total
GEIGER COUNTERS
• R1: False negatives from Geiger tubes IF voltage leaks

MICHELSON INTERFEROMETER
• R2: Misalignment of mirrors IF vibrations exceed expectations

INERTIAL MEASUREMENT UNIT
• R3: Difficulty diagnosing interferometer problems IF IMU readings are off

SI PIN DETECTOR
• R4: Mission objectives aren’t met IF Si PIN Photodiode Detector fails in-flight
What has been prototyped?
- We have prototyped the Geiger Tubes circuits
- The result from those prototypes has been the elimination of one design for the circuits

In the very near future our plan is to finish prototyping the Geiger circuits and prototype the interferometer.

These plans will lead us to our goal of completing our payload on time and ready for flight.
MANUFACTURING PLAN

MECHANICAL / ELECTRICAL

• The Geiger tubes themselves, the parts for the circuits and pieces of lab tech for the interferometer have been purchased and for the most part procured
• The plan is to start manufacturing over Winter break and have most to all of our prototyping done
• Prototypes of the Geiger tubes circuits, IMU and interferometer will be finished by the end of January
• The subsystems will be integrated and tested by the end of February
• PCBs will be designed by the end of March
• PCBs will be populated and the full payload built by end of April and ready for flight by the end of May

SOFTWARE

• Geiger circuit code
  – Based on previous projects – Now much communicate via I2C instead of UART
  – This code will depend on Raspberry Pi to transmit results via Telemetry
• Raspberry Pi (Interferometer) code
  – Entirely new code has to be written based on the well developed OpenCV library
  – Raspberry Pi will depend on Geiger circuit code to collect data from other subsystems
MECHANICAL / ELECTRICAL
• Geiger counters and Si PIN Photodiode Detectors will be exposed to radiation sources
• Microgravity chamber will be used to simulate the effects of acceleration on all subsystems
• Subwoofer will be used to simulate the effects of engine vibration on the Interferometer and other subsystems

SOFTWARE
• Software testing of Interferometer code will depend on physical prototyping
• Geiger circuit code will be tested by simulating radiation with a waveform generator
  – This test will determine how fast the microcontroller can take readings and how many circuits it can handle

SYSTEM LEVEL
• The payload will be tested and made flight ready by end of May
• Integrated payload will be tested by connecting payload to a computer
  – This test will determine how well the payload transmits data over UART Telemetry line
• The same tests of the subsystems will be performed again after integrating the payload together
WVU – SUBORBITAL REENTRY PAYLOAD

SEBASTIAN REGER
MISSION OVERVIEW

To evaluate the capabilities of a jettisoned capsule to project individual experiments in future missions.

• MISSION OBJECTIVES:
  1. Collect and wirelessly send data detailing the environment of the capsule during reentry.
  2. Design an aerodynamic capsule, capable of withstanding the effects experienced during reentry.

• MINIMUM SUCCESS CRITERIA:
  1. Meaningful data was sent wirelessly by the capsule back to the rocket.

• COMPREHENSIVE SUCCESS:
  1. Electronics survive re-entry until splashdown
  2. Experiment is locatable via GPS (once at a low enough altitude) until splashdown
- Modifying RSX-17’s “Chalice” structure to jettison SRP.
MECHANICAL DESIGN - LAUNCH MECHANISM

- Capsule Holder
- Section for Wire Coils
- Spaces for Magnets
Design is NOT Finalized

- STILL NEEDED:
  - Flight Dynamics Sensor
  - 3.7 V to 3.3 V Low Drop Out Converter (LT1763)
  - Xbee-PRO S3B Module
  - Battery Latching Circuit (with pins to delatch the circuit at easy access)
  - Battery & Connector

- Do NOT plan to use the RTC located on the MT3339 GPS unit
XBEE-PRO S3B RF MODULE

• Used to transmit/receive data from the ejected payload back to the rocket.
• Receiving XBee radio will be mounted on the DAQ board and wired directly to its serial line
• Data will be sent at the specified baud rate to the SD card for local storage and sent to Wallops Telemetry.
• The XBee radio allows an outdoor line-of-sight wireless range up to 28 miles
• Operates at 250 mW in the 900 MHz range with frequency hopping
• The current antenna is an integrated wire, but a different antenna is expected to be chosen in the future
SOFTWARE DESIGN

- Once all variables and serial buses are initialized, a structure is created with a header, footer, identifiers, and data.
- This data is converted into byte format and streamed in a packet to the receiver.
- Once the data is received, it is collected directly by the DAQ at the specified baud rate.
• R1 – Minimum mission success is not met IF the capsule does not deploy
  • Similar conditions will be replicated in WVU’s subsonic wind tunnel

• R2 – Minimum mission success is not met IF the wireless modules do not connect

• R3 – Comprehensive mission success is not met IF the parachute does not deploy
  • Chute deployment can also be tested in the subsonic wind tunnel
PROTOTYPING & ANALYSIS

- MCU has been interfaced with several subsystems (MAX31865 & RTD, MT3339 GPS module)
- The XBee-PRO S3B was prototyped through RSX-17
- The electromagnetic launching mechanism was prototyped
  - Capacitors were simulated being charged by GSE-2 (28 V)
  - Once the rocket reaches apogee, a MOSFET will receive a timer event signal (modulated to 3.3V by the DAQ board)
  - This was simulated by establishing a connection between the coil and the circuit
  - Then, the capacitor bank will discharge across the coil, which will project the capsule from the launcher

RESULTS

- Less force was applied on the magnet (treated as the capsule) than expected
  - By adding more turns to the coil and reducing the load with a more sophisticated design (less alligator clips) we believe the force can be dramatically increased
PROTOTYPING PLAN

ELECTRICAL/SOFTWARE
• Continue prototyping all subsystems by December 23rd
• Complete an integrated setup as seen on the right prototyping all components by return for Spring semester (January 8th)
  – Heritage code and online resources can be utilized to streamline this process

MECHANICAL/AEROSPACE
• With a stronger understanding of the principles of Electromagnetics, modify the design in the Mechanical design to operate effectively with an electromagnetic launcher by January 15th
• Perform more testing to further finalize design by January 8th (This will aid in the modification of the mechanical design)
MANUFACTURING PLAN

MECHANICAL/ELECTRICAL
• The Arduino Pro Mini, MAX31865 RTD Amplifier, RTD, XBee-PRO S3B, and MT3339 GPS module have been procured.
• A Flight Dynamics sensor will be procured as soon as a spin rate approximation is made
  – OFF RAMP: Inertial Measurement Unit
• Schematic design must be completed by the end of break to achieve January push objective
• A PCB is planned to be fabricated by the end of January to mid February
  – This is dependent upon the final dimensions of the capsule

SOFTWARE
• Most software was written for RSX17
• Modifications include implementing the GPS unit and Flight Dynamics Sensor
MECHANICAL/AEROSPACE
• Experiment will be measured with each redesign to ensure it remains within size and weight constraints
• Heat transfer/strain testing can be performed in SolidWorks as the design is finalized
• A vibe table in the local area can be utilized to test the retention capabilities of the magnets during launch

ELECTRICAL/SOFTWARE
• Range testing will be performed on the XBee modules after the initial PCB design
• The data rate of the XBee modules at long range will be tested
  – Creates opportunity to improve the efficiency of our data rate
WVU – PLASMA SPECTROMETER
GREG LUSK
MISSION OVERVIEW

To design an ultra-compact plasma spectrometer, with reduced mass, volume, and high voltage required, compared to identical instruments.

MISSION OBJECTIVES:

1. Detect charged particles in the ionosphere
   - Primary sources of energetic electrons: magnetic reconnections & losses from radiation belt

2. Prove the effectiveness of the plasma spectrometer electronics and data acquisition techniques.

MINIMUM SUCCESS CRITERIA:

- Capture an increased number of pulses in ionosphere compared to detections that occur on the ground (shouldn’t detect any on the ground), especially when detector entrance door is closed.

COMPREHENSIVE SUCCESS CRITERIA:

- Capture several pulse waveforms while at apogee, especially when detector entrance points zenith. Prove ability to determine energy and number of detections.
• **SPECTROMETER ENCLOSURE:**
  – Reuse design from last year with improvements to prevent water penetration.
  – Modified, off-the-shelf aluminum enclosure.
  – 115 mm height, 83 mm width, 40 mm depth
PROGRESS SINCE LAST TAG-UP:

- Analog conditioning daughter board has been designed and manufactured
- Analog conditioning circuitry moved inside Spectrometer enclosure to eliminate noise problem on RSX-17
- Same circuitry as used previously with layout improvement
• Our data acquisition scheme is as follows:
  – The pulses produced by the detector and charge-to-voltage amplifier are negative going
  – Continuously sample our 14-bit ADC at 125MS/s and store in RAM
  – Determine a trigger location at some amplitude on the falling edge of the pulse
  – Store approximately 20 samples before the trigger location and 60 samples after the trigger, allowing us to record the pulse for post processing. This allows us to analyze the pulse waveform and determine that detections are not false positives. Sample waveform on following slide.
  – Produces a lot of data requiring the use of local storage instead of using telemetry.
• R1: Mission objectives aren't met IF noise issues can't be eliminated and nothing is detected

• R2: Mission objectives aren't met IF the detection threshold or the gain is set too low

• R3: Mission objectives aren't met because of a software bug or hardware failure
The spectrometer enclosure was designed and built for RSX-2017.

- A seal between the lid (back) of the enclosure and a spacer that bolts to the hermetic connector leaked.
- A new lid will be machined, integrating the spacer, eliminating the opportunity of a leak at location.

The detector PCB will be reused from last year.

- Some components will be removed or changed to optimize the design.
  - The detector bias power supply will be removed and moved to the PDB/telemetry board to remove high frequency switching noise from the enclosure.
  - A daughter board will be added for the new analog conditioning circuitry.

The detector acquisition software is written but needs additional testing.

Additional software will be added to sample TE line for time synchronization to Wallops mission time and flight dynamics.
TESTING PLAN

• The gain of the analog conditioning circuitry will be set to 100 V/V for full system testing with the Americium sample which produces an energy of 6 MeV.

• The gain will be increased to 1000 V/V for the mission configuration and additional testing will be done to evaluate the amount of noise present in the system. Additional tweaks to the analog circuitry may be required with continued testing if noise level isn’t acceptable.

• Full system testing may be attempted using some sort of attenuator to reduce the energy produced by the Americium, allowing testing to be done at light gain levels. Space energy is expected to be 10KeV max.
WEST VIRGINIA WESLEYAN COLLEGE

ANGELA MEYERS
MISSION OVERVIEW

To compare the effectiveness of a thermionic converter to a solar panel in space, and to prove NOAA magnetometer data

MISSION OBJECTIVES:
1. Evaluate the benefits of using a thermionic converter over a solar panel
   - Ex. Benefits: cost, voltage gained, space

2. Assess the accuracy of the Adafruit magnetometer by comparing to NOAA magnetometer data. NOAA data will also be used to map time variations in the magnetic field.

MINIMUM SUCCESS CRITERIA:
1. Collect all three components of the magnetic field during the entire flight.

2. To develop a fully operational thermionic converter with comparable data to the solar panel

3. The solar thermionic converter would have to work in space, but not collect a lot of voltage.

COMPREHENSIVE SUCCESS CRITERIA:
1. The solar thermionic converter would have to work in space and collect a voltage greater than or equal to the solar panel
- PCB Dimensions: 3-1/4” x 4”
- Solar panel 2.25”x2.25”
- STC 2”x2”
- Material choices in progress
SOFTWARE DESIGN

- INPUT: Data from magnetometer, STC, Solar Panel
- OUTPUT: Openlog and UART pin
- The thermocouple and Arduino code will be tweaked from last years WVWC RockSat-C code
- The magnetometers code will be found online in databases and tweaked
POWER AND DATA
• The Magnetometer will receive 5v
• The Arduino will receive all data from the magnetometer
MECHANICAL AND ELECTRICAL
• Magnetometer will be attached to the PCB and will be inside the enclosure
DESIGN
• The design is final
• Coding and electrical testing will be completed in early spring
• Power and Data
  – The 3.3v regulator will give power to the thermocouple and logic level
  – The thermocouple will receive a temperature from the Al bar and convert it to a voltage. The Arduino receives data from the thermocouple.

• Mechanical and Electrical
  – Parabola made out of a reflective metal/material
  – Al bar placed at the focus – Light reflects off the parabola and heats the bar
  – Structure built around the parabola to prevent warping
  – Lid needed for insulation
  – Valve needed for pressure release
  – Thermocouple wires secured in notches in the Al bar
  – An adhesive is used to connect the thermocouple wires to the bar
SOLAR PANEL

POWER AND DATA
• More tests have to be conducted to see what power is required. The data will be sent to the Arduino Pro Micro

MECHANICAL AND ELECTRICAL
• The plastic holding the SP will be cut to a shorter height. The Area is 2” x 2”
• The thickness of the solar panel will be shaved off to minimize size

DESIGN
• A different/larger SP might be purchased after more testing is done.
R1 – Mission objectives aren't met if STC doesn't release pressure due to mechanical failure
R2 – Mission objectives aren't met if STC isn't insulated due to poor material choice
R3 – Mission objectives aren't met if STC isn't stable due to mechanical failure
R4 – Mission objectives aren't met if the thermocouple wires don't stay secure
R5 – Mission objectives aren't met if the solar panel or STC are not facing the sun
We’ve already begun small tests with the solar thermionic converter with random materials to get a better understanding of what factors we need to keep in mind – insulation, reflectiveness of the parabola, shape of the parabola, finding the focus, etc.

- **STC Testing**
  - Build STC: January-March
  - Electrical testing: January-February
  - Software testing: February-March

- **Magnetometer Testing**
  - Electrical testing: January
  - Software testing: February-March
  - Balloon, drone, possible airplane flight: March-May
## MANUFACTURING PLAN

### Manufacturing plan/schedule

<table>
<thead>
<tr>
<th>Manufactured</th>
<th>Purchase</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parabola for STC</td>
<td>Reflective material</td>
<td>January</td>
</tr>
<tr>
<td>Structure for STC</td>
<td>Sturdy material</td>
<td>February</td>
</tr>
<tr>
<td>Insulation for STC</td>
<td>Sturdy clear material</td>
<td>February</td>
</tr>
<tr>
<td>PCB</td>
<td>ExpressPCB</td>
<td>Late March/Early May</td>
</tr>
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</table>

### Electrical Plan/Schedule

<table>
<thead>
<tr>
<th>Manufactured/soldered</th>
<th>Revisions</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>STC inside components</td>
<td>3</td>
<td>January-February</td>
</tr>
<tr>
<td>Magnetometer</td>
<td>3</td>
<td>January-February</td>
</tr>
<tr>
<td>Solar Panel</td>
<td>3</td>
<td>February</td>
</tr>
</tbody>
</table>

### Software plan/schedule

<table>
<thead>
<tr>
<th>Code</th>
<th>Dependence</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetometer</td>
<td>Depends on Arduino Pro Micro</td>
<td>February-March</td>
</tr>
<tr>
<td>Thermocouple</td>
<td>Depends on Arduino Pro Micro</td>
<td>February-March</td>
</tr>
<tr>
<td>Arduino Pro Micro</td>
<td>Depends on Openlog and UART pin</td>
<td>March</td>
</tr>
</tbody>
</table>
MECHANICAL / ELECTRICAL

- Building prototypes of the STC will show us insight on the weight we would expect (January-February)
- Communication will allow the placement needed for ideal data
- Vibration tests will be conducted on WVWC’s vibration table to ensure the STC is sturdy (February-March)
- Test the operation of the magnetometer with a drone
- Testing the thermocouple and Arduino Pro Micro (February)
- Testing the thermocouple with the STC (March)

SOFTWARE

- All components must turn on for the software testing to begin (January)
- The Arduino Pro Micro, Thermocouple, And Magnetometer need to have completed code to test for data (January-February)

SYSTEM LEVEL

- STC testing with light from the light bulb and Sun (March-May)
  - Test the thermocouple without the STC and then with
  - Integrate onto the PCB
- Magnetometer testing with using different altitudes (March-May)
  - Once testing has completed successfully, it will be integrated and tested on the PCB.
SUBSYSTEM DESIGN: SYSTEM LEVEL

GREG LUSK & SEBASTIAN REGER
POWER DISTRIBUTION SYSTEM

- Provides experiments with ~5 V (4.8 – 5.2 V depending on current)
- Contains a single protected 18650 Lithium-ion 3.7 V 3200 mAh battery
  - Provides power to experiments as needed through reentry
  - Battery is NOT charged with GSE and requires external charging prior to launch
- The figure shows the latching circuit used on RSX17 to transition from GSE power to the battery
  - Latch connects the internal battery once GSE is active
  - The schottky diode is reverse-biased when GSE is active
  - Once GSE turns off, the diode is forward biased and allows the experiments to be powered via the battery.
- The internal battery can be delatched by shorting two pins on a debug connector located on the payload deck.
  - **This will be necessary after each sequence test at Wallops**
- Board dimensions specified
- Determining pinout for interface to the backplane board
R1 – If one experiment draws too much power from the Power Distribution System
• Breaker installed to catch issue to save other experiments. Affected experiment flips on and off throughout flight
• Teams were notified early of their power restrictions. Given a team needs a higher current

R2 – Bolt comes loose inside enclosure and shorts two connections on PDS.
• Ensure components are well secured, use have a backup board for launch.
DATA ACQUISITION BOARD

- Reads asynchronous serial data from experiments on-board payload.
  - Packages the data and sends it to the Wallops telemetry via 16-bit parallel lines with a strobe line
  - Each packet of data begins with header, has an identifier, and ends with a footer.
    - Packets deconstructed post launch for individual experimental analysis
- Accepts data stream from experiments at 57,600 baud rate.

SUBSYSTEM DESIGN IS NOT FINAL

TO BE COMPLETED:
- UART 9 changed to UART 0
- No other changes – 4 payloads are still sending us data like in RSX-17
SD Card: Duplicate Local Data

Netburner Nano

Shift Registers

3.3V to 5V bus translators

Quad Isolated UART Inputs

DATA ACQUISITION SYSTEM – Schematic
R1 – If all teams saturated their data at the specified baud rate, the Telemetry System might not have enough time to transmit all data to Wallops Telemetry system before GSE is cut.
- By performing our own April sequence testing, we will be able to mitigate this risk.
- Data is also stored locally on the DAQ Board

R2 – Bolt comes loose inside enclosure and shorts two connections on the DAQ Board.
- Ensure components are well secured, use have a backup board for launch.

R3 – From past experience, Wallop's wireless telemetry system does occasionally parts of data packets.
- We use headers and footers to indicate a something was lost
- This is why we store locally and encourage teams with consistent data transmission to store locally
• The Backplane board is mounted within the processing enclosure on 1/8” standoffs

• Interfaces with teams through 48 pin connectors

• Lines that must connect externally to the enclosure are traced to one of the 44 pin connectors.

• The other 44 pin connector is used to interface the PDS & DAQ with Wallops

SUBSYSTEM DESIGN IS NOT FINAL

TO BE COMPLETED:
• Double check required pins by each team
• Establish pinout for each team and start laying traces
R1 – Misalignment of male to female connectors from backplane board to experiment payloads could set back initial fit testing
- Plans to send board template to teams. If they fit their holes/PCB edges line up with the template, they will fit
- Could easily make modifications to backplane board after January Testing.

R2 – Miscommunication between teams and project management team on pinout
- Easily fixable through a backplane board revision
• The Power Distribution System (PDS), data acquisition board (DAQ), and all experiment boards are housed within the processing enclosure.
• A backplane, connector board is designed to interface with the components outside the enclosure.
• The enclosure holds 6 boards (1 for each experiment and 2 for the power and DAQ boards).
• We will handle all testing of the enclosure at WVU to relieve teams of designing their own enclosure and to reduce used space on the deck.
• Each board is provided an inch of space unless we are notified otherwise.
• Walls are currently half an inch thick. These will be shaved down as needed for weight constraints.
• 1/8” grooves are machined for each board for more support throughout the launch.

SUBSYSTEM DESIGN IS NOT FINAL

TO BE COMPLETED:
• Need to reduce max height – shared plate not accounted for.
• Plan to remove bottom of enclosure and reduce thickness of lid to 1/8”.

PROCESSING ENCLOSURE
R1 – Leak in water seal of processing enclosure
• Plans to finalize for interior next month for early machining of processing enclosure
• The earlier the enclosure can be machined, the sooner the welds can be tested for holes.

R2 – Experiment boards may not be the same width as what the processing enclosure allows
• We plan to send out a template board which teams can line up their initial PCB design as a preliminary fit check

R3 – Experiments could shake loose of the connector during launch or reentry
• By placing a foam material across the top of the boards, we are creating a resistive material that will not allow the boards to become unplugged, while adding a small buffer at the top of the enclosure in case a board is too long.
PROTOTYPING/ANALYTIC RESULTS/PLAN
SEBASTIAN REGER
PROTOTYPING RESULTS/PLAN

PROTOTYPING

• Everything electrical system-level, except for the Backplane Board is heritage
• Backplane Board design has been modeled and matched with Processing Enclosure model
• Everything mechanical system-level has been modeled.
  – Full Payload
  – Processing Enclosure
• Prototyped slots for boards to test tolerances

RESULTS

• We were able to find a suitable tolerance for the experiment boards
• We understand how and where everything will fit on the deck
• In RSX17, all system-level electrical systems operated correctly

SUMMARY

System-Level, we are well on track to handle each of our science objectives for the mission

PLAN

• Four 0.5” thickness Aluminum 6061 Plates will be purchased through McMaster-Carr and machined to match the Processing Enclosure model. These will be screwed together for the end of January midpoint review
• At this same midpoint review, all initial system designs will be tested, including the PDS, DAQ, Backplane Board, and the Full Model layout.
MANUFACTURING PLAN
SEBASTIAN REGER
• If the Processing Enclosure used for prototyping in the January Midpoint Review tested successfully, the plates will be welded together.

• Once we receive the deck from Wallops and are confident in the full deck layout, we will weld the enclosure to the deck.

• All system-level PCB’s must be fabricated and soldered for their initial design by the January Midpoint Review.
PURCHASE LIST

- 4 Aluminum plates of 0.5” thickness, exceeding the dimensions of each wall of the enclosure
- 8 48 pin connectors – to interface with each experiment (with margin)
- 44 pin male and female connectors to interface with the exterior of the enclosure
- O-Ring
- 1/8” standoffs for backplane board
• SYSTEM-LEVEL ELECTRICAL COMPONENTS: Data Acquisition Board, Power Distribution Board, and Backplane Board
• Each board anticipates 1 or maybe 2 revisions after the January Midpoint Review
• Most components must be procured for each board
  – The only components that are not needed are extra components from last year’s flight
• All boards will be fabricated and soldered by the January Midpoint Review
System-Level, the only software is used in the Data Acquisition Board to handle converting multiple data streams into a singular stream. This singular stream is sent through the 16 bit parallel interface.

Software design tested successfully on RSX-17 with the same number of incoming data streams we will be experiencing on RSX-18.

STILL NEEDS TO BE COMPLETED

- Not use UART 9 on NetBurner and use UART 0. This was one of our receiving lines from last year. The switch will improve capabilities of the UART line, providing a faster line with a larger buffer for the experiment.
- Shuffle parallel bits on our shift registers. Last year, the nibbles in our parallel interface were flipped, as well as the bytes in the 16 bits. This complicated deciphering the data in post-launch analysis.

TIME PERMITTING

- We are able to manually flip GSE and our Timer Events on for testing, but it would be nice to make an automated system to perform sequence testing on our payload prior to showing up in June.
## Manufacturing Plan

<table>
<thead>
<tr>
<th>Step Description</th>
<th>Task Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within the next few days</td>
<td>Purchase all parts for the January Midpoint Review</td>
</tr>
<tr>
<td></td>
<td>within the next few days</td>
</tr>
<tr>
<td>As soon as parts come in</td>
<td>Machine deck and plates to correct size with grooves</td>
</tr>
<tr>
<td>While waiting for sidewalls to be machined</td>
<td>Finalize PCB designs for system-level boards</td>
</tr>
<tr>
<td>Once sidewalls are machined</td>
<td>Drill holes in the enclosure and screw it together</td>
</tr>
<tr>
<td>As PCB designs are finished</td>
<td>Send in Gerber files to fabricate PCBs</td>
</tr>
<tr>
<td>Once PCBs come in</td>
<td>Solder components onto PCBs</td>
</tr>
</tbody>
</table>
MECHANICAL TESTING

• Initial weight measurement of full payload will be taken in January for approximation and again in April for the Full-Mission Simulation Tag-up.
• As system-level components are procured, the weight will be taken to update the spreadsheet.
• As changes are made in the experimental or system-level design, the full payload model will be updated to reflect the changes.
• A vibration table will be located in the nearby area for use in the Full-Mission Simulation Tag-up in April.
TESTING SCHEDULE:

- By the last week of January
  - PDS: Use dummy loads to ensure that PDS is capable of outputting the required power to each experiment and ensure components are operating under their thermal capabilities
  - Test the onboard battery – Allows teams to have power after GSE is cut
  - Timed event distribution system must be ready for testing
  - First version of backplane board fabricated and ensured to be the correct dimensions, with electrical interface connections in the correct location and at the correct signal level
  - Telemetry board will be tested by receiving erroneous but known data from each payload
  - This will be tested via the system in the figure. It simulates Wallops telemetry system

- By April Full Mission Simulation
  - Experiments must be ready to deliver to IV&V for integration and testing
  - Sequence testing will be performed to guarantee system-level and experimental readiness

- After June Wallops Testing
  - Address any issues discovered during June visit
  - Additional sequence testing
JANUARY MIDPOINT REVIEW
• Teams will be tested for fitting, power, and telemetry capabilities
• Testing also the capabilities of the system-level subsystems
• All experiments will be tested for the following
  – Integration into the enclosure and onto the deck
  – Teams will be tested for receiving the correct power out of their converters and from our PDS
  – Teams will send erroneous data to our Data Acquisition System to test the capabilities of the Telemetry system
  – This whole endeavor is to take advantage of the free time in the beginning of the semester
  – January Testing may be pushed back to mid February as needed

BY APRIL FULL MISSION SIMULATION
• Experiments must be ready to deliver to IV&V for integration and testing
• Sequence testing will be performed to guarantee system-level and experimental readiness

AFTER JUNE WALLOPS TESTING
• Address any issues discovered during June visit & continue additional sequence testing
USER GUIDE COMPLIANCE

SEBASTIAN REGER
<table>
<thead>
<tr>
<th>Requirement</th>
<th>Status/Reason (if needed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center of gravity in 1&quot; plane of plate?</td>
<td>0.8” -- YES</td>
</tr>
<tr>
<td>Weight 30.0+/- 1.0 (15.0 +/- 0.5) lbs?</td>
<td>14.992</td>
</tr>
<tr>
<td>Max Height &lt; 10.75” (5.13”)</td>
<td>NO, max height: 5.18” – SEE PLAN FOR CORRECTION @ PE SLIDES</td>
</tr>
<tr>
<td>Bottom of deck has flush mount hardware?</td>
<td>NO</td>
</tr>
<tr>
<td>Within Keep-Out Zone</td>
<td>NO, SEE MECHANICAL LAYOUT</td>
</tr>
<tr>
<td>Using &lt; 10 A/D Lines</td>
<td>NO TEAM REQUIRES A/D LINES</td>
</tr>
<tr>
<td>Using/Understand Parallel Line</td>
<td>YES – Using 16 parallel bit lines with strobe line</td>
</tr>
<tr>
<td>Using/Understand Asynchronous Line</td>
<td>NO</td>
</tr>
<tr>
<td>Using X GSE Line(s)</td>
<td>GSE 2</td>
</tr>
<tr>
<td>Using X Non-Redundant PWR Lines (TE-1, TE-2, TE-3)</td>
<td>TE2 &amp; TE3</td>
</tr>
<tr>
<td>Using X Redundant Power Lines (TE-R)</td>
<td>N/A</td>
</tr>
<tr>
<td>Using &lt; 1 Ah</td>
<td>YES</td>
</tr>
<tr>
<td>Using &lt;= 28 V</td>
<td>YES</td>
</tr>
<tr>
<td>Using RF (If yes, list frequency and TX Power)</td>
<td>YES, 900 MHz @ 250 mW TX Power</td>
</tr>
<tr>
<td>Using deployable?</td>
<td>YES</td>
</tr>
<tr>
<td>Whole team consists of US Persons</td>
<td>NO, two permanent residents</td>
</tr>
<tr>
<td>Using ITAR and/or Export Controlled hardware</td>
<td>NO</td>
</tr>
</tbody>
</table>
## SFDC Power Connector -- Customer Side

<table>
<thead>
<tr>
<th>PIN</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N/C</td>
</tr>
<tr>
<td>2</td>
<td>N/C</td>
</tr>
<tr>
<td>3</td>
<td>N/C</td>
</tr>
<tr>
<td>4</td>
<td>N/C</td>
</tr>
<tr>
<td>5</td>
<td>N/C</td>
</tr>
<tr>
<td>6</td>
<td>N/C</td>
</tr>
<tr>
<td>7</td>
<td>N/C</td>
</tr>
<tr>
<td>8</td>
<td>N/C</td>
</tr>
<tr>
<td>9</td>
<td>+28 Volts</td>
</tr>
<tr>
<td>10</td>
<td>Timer Event 2 (TE2)</td>
</tr>
<tr>
<td>11</td>
<td>Timer Event 3 (TE3)</td>
</tr>
<tr>
<td>12</td>
<td>GND</td>
</tr>
<tr>
<td>13</td>
<td>GND</td>
</tr>
<tr>
<td>14</td>
<td>GND</td>
</tr>
<tr>
<td>15</td>
<td>GND</td>
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To be confirmed by Colorado
### SFDC Telemetry Connector -- Customer Side

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<th>Function</th>
<th>PIN</th>
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<tbody>
<tr>
<td>1</td>
<td>N/C</td>
<td>20</td>
<td>Parallel Bit 7</td>
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<tr>
<td>2</td>
<td>N/C</td>
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<td>Parallel Bit 8</td>
</tr>
<tr>
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<td>N/C</td>
<td>22</td>
<td>Parallel Bit 9</td>
</tr>
<tr>
<td>4</td>
<td>N/C</td>
<td>23</td>
<td>Parallel Bit 10</td>
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<td>N/C</td>
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<td>Parallel Bit 11</td>
</tr>
<tr>
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<td>N/C</td>
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<td>Parallel Bit 12</td>
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<tr>
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<td>N/C</td>
<td>26</td>
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<td>N/C</td>
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<td>N/C</td>
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<td>N/C</td>
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<td>Parallel Bit 16</td>
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<tr>
<td>11</td>
<td>Parallel Bit 1 (MSB)</td>
<td>30</td>
<td>Parallel Read Strobe</td>
</tr>
<tr>
<td>12</td>
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To be confirmed by Colorado
PROJECT MANAGEMENT PLAN
### Preliminary Schedule – Spring

<table>
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<tr>
<th>Date Range</th>
<th>Event Description</th>
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<tr>
<td>Last week of January</td>
<td><strong>January Midpoint Review at NASA IV&amp;V Facility:</strong></td>
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<tr>
<td></td>
<td>• Testing for System-Level Subsystems</td>
</tr>
<tr>
<td></td>
<td>• Initial PCB designs made for teams</td>
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<tr>
<td></td>
<td>• Major components soldered onto PCB’s</td>
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<tr>
<td>First week of March</td>
<td><strong>Teams send in PCB revision based on testing found in January</strong></td>
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<tr>
<td>End of April Tagup</td>
<td><strong>Final integration/round of testing before June</strong></td>
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<tr>
<td></td>
<td>• Sequence testing</td>
</tr>
<tr>
<td></td>
<td>• Power on</td>
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<tr>
<td></td>
<td>• Test telemetry with all 4 payloads sending data</td>
</tr>
</tbody>
</table>
TEAM MENTORS

NASA IV&V
Marcus Fisher – Chief Engineer

West Virginia State University
Marek Krasnansky, Ph. D

West Virginia Wesleyan College
Tracey DeLaney, Ph. D

West Virginia University
Jeremy Dawson, Ph. D

Marshall University
Jon Saken, Ph. D

Hobart & William Smith Colleges
Peter Spacher, Ph. D & Ileana Dumitriu, Ph. D

West Virginia University
Jason Gross, Ph. D
<table>
<thead>
<tr>
<th>RockSat-X</th>
<th># of RockSat-X Teams</th>
<th># of Travelers per Team (for Wallops Launch)</th>
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<tr>
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<tr>
<td>Supplies for payload construction ($500 per team)</td>
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<td>Launch charge for RockSat-X (Half-Deck)</td>
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<td>Travel to IV&amp;V for RockSat-X face-to-face design review (Lodging: 1 night, $150/night, 1 room per team)</td>
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<td>Mileage/rental for travel to IV&amp;V ($100 per team)</td>
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<tr>
<td>Travel to IV&amp;V for RockSat-X full mission simulation review (Lodging: 1 night, $150/night, 1 room per team)</td>
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<td>Mileage/rental for travel to IV&amp;V ($100 per team)</td>
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<tr>
<td>Travel to Wallops for RockSat-X Integration &amp; Testing (Lodging: 5 nights, $150/night, 1 room per team (leads only), plus Lusk and Sebastian)</td>
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<td>Per diem for Integration &amp; Testing (5 days, $50/day, 1 traveler per team (leads only), plus Lusk and Sebastian)</td>
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<tr>
<td>Travel to Wallops for Launch (Lodging: 1 room per traveler (based on # of teams above), plus 2 rooms for Lusk and Sebastian for 8 nights, $125/night)</td>
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<td>Per diem ($50/day)</td>
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<td>Mileage/rental for travel to Wallops for RockSat-X ($250 per team)</td>
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<tr>
<td>RockSat Registration (T-shirt &amp; Launch Dinner, $70 per 15 travelers)</td>
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<td><strong>Total for RockSat X</strong></td>
<td><strong>$36,450</strong></td>
<td><strong>$14,000</strong></td>
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**$22,450**
## CONTACT MATRIX

### WV-Collaboration

#### Fall 2017 RS-X Contact Matrix

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
<th>Day Phone</th>
<th>Cell Phone</th>
<th>Receive Texts?</th>
<th>Email</th>
<th>Citizenship</th>
<th>Add to mailing list?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Manager</td>
<td>Sebastian Reger</td>
<td>(304) 940-9125</td>
<td>(304) 940-9125</td>
<td>Yes</td>
<td><a href="mailto:sebastian.w.reger@iiv.nasa.gov">sebastian.w.reger@iiv.nasa.gov</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Deputy Project Manager</td>
<td>Emily Certain</td>
<td>(304) 288-5759</td>
<td>(304) 288-5760</td>
<td>Yes</td>
<td><a href="mailto:emily.c.certain@nasa.gov">emily.c.certain@nasa.gov</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Electrical Lead</td>
<td>Greg Lusk</td>
<td>(724) 498-3385</td>
<td>(724) 498-3385</td>
<td>Yes</td>
<td><a href="mailto:grglusk@gmail.com">grglusk@gmail.com</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Mechanical Lead</td>
<td>Jared Beard</td>
<td>(304) 288-5638</td>
<td>(304) 288-5638</td>
<td>Yes</td>
<td><a href="mailto:jbeard6@mix.wvu.edu">jbeard6@mix.wvu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Software Lead</td>
<td>Matt Gramlich</td>
<td>(304) 541-1965</td>
<td>(304) 541-1965</td>
<td>Yes</td>
<td><a href="mailto:mgramlich@mix.wvu.edu">mgramlich@mix.wvu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>HWS Advisor</td>
<td>Peter J Spacher</td>
<td>(585) 507-6558</td>
<td>(585) 507-6558</td>
<td>Yes</td>
<td><a href="mailto:spacher@hws.edu">spacher@hws.edu</a></td>
<td>U.S.</td>
<td>No</td>
</tr>
<tr>
<td>HWS Advisor</td>
<td>ileana Dumitriu</td>
<td>(269) 312-3540</td>
<td>(269) 312-3540</td>
<td>Yes</td>
<td><a href="mailto:dumitriu@hws.edu">dumitriu@hws.edu</a></td>
<td>U.S.</td>
<td>No</td>
</tr>
<tr>
<td>HWS Team Lead</td>
<td>Elizabeth Moore</td>
<td>(716) 597-6469</td>
<td>(716) 597-6469</td>
<td>Yes</td>
<td><a href="mailto:elizabeth.moore@hws.edu">elizabeth.moore@hws.edu</a></td>
<td>U.S.</td>
<td>No</td>
</tr>
<tr>
<td>HWS Team Lead</td>
<td>Joshua Andrews</td>
<td>(315) 391-0417</td>
<td>(315) 391-0417</td>
<td>Yes</td>
<td><a href="mailto:joshua.andrews@hws.edu">joshua.andrews@hws.edu</a></td>
<td>U.S.</td>
<td>No</td>
</tr>
<tr>
<td>MU Advisor</td>
<td>Jon Saken</td>
<td></td>
<td></td>
<td></td>
<td><a href="mailto:saken@marshall.edu">saken@marshall.edu</a></td>
<td>U.S.</td>
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<tr>
<td>MU Team Lead</td>
<td>Mayson Pine</td>
<td>(304) 308-4375</td>
<td>(304) 308-4375</td>
<td>Yes</td>
<td><a href="mailto:pine2@marshall.edu">pine2@marshall.edu</a></td>
<td>U.S.</td>
<td>No</td>
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<tr>
<td>WVSU Advisor</td>
<td>Marek Kranzansky</td>
<td></td>
<td></td>
<td>Yes</td>
<td><a href="mailto:mkrasnansky@wvstateu.edu">mkrasnansky@wvstateu.edu</a></td>
<td>U.S.</td>
<td>No</td>
</tr>
<tr>
<td>WVSU Software Lead</td>
<td>Jonathan Musselwhite</td>
<td>(304) 719-7914</td>
<td>(304) 719-7914</td>
<td>Yes</td>
<td><a href="mailto:jmusselwhite@wvstateu.edu">jmusselwhite@wvstateu.edu</a></td>
<td>U.S.</td>
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</tr>
<tr>
<td>WVSU Mechanical Lead</td>
<td>Jordan Thompson</td>
<td>(304) 444-1398</td>
<td>(304) 444-1398</td>
<td>Yes</td>
<td><a href="mailto:jthompson17@wvstateu.edu">jthompson17@wvstateu.edu</a></td>
<td>U.S.</td>
<td>No</td>
</tr>
<tr>
<td>WVU-Plus Team Lead</td>
<td>Sebastian Reger</td>
<td>(304) 940-9125</td>
<td>(304) 940-9125</td>
<td>Yes</td>
<td><a href="mailto:sebastian.w.reger@iiv.nasa.gov">sebastian.w.reger@iiv.nasa.gov</a></td>
<td>U.S.</td>
<td>No</td>
</tr>
<tr>
<td>WVU-Plus Team Lead</td>
<td>Greg Lusk</td>
<td>(724) 498-3385</td>
<td>(724) 498-3385</td>
<td>Yes</td>
<td><a href="mailto:grglusk@gmail.com">grglusk@gmail.com</a></td>
<td>U.S.</td>
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</tr>
<tr>
<td>WVU-Plus Team Lead</td>
<td>Matt Gramlich</td>
<td>(304) 541-1965</td>
<td>(304) 541-1965</td>
<td>Yes</td>
<td><a href="mailto:mgramlich@mix.wvu.edu">mgramlich@mix.wvu.edu</a></td>
<td>U.S.</td>
<td>No</td>
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<tr>
<td>WVVW Advisor</td>
<td>Tracey DeLaney</td>
<td>(304) 473-8330</td>
<td>(304) 473-8330</td>
<td>Yes</td>
<td><a href="mailto:delaney_t@wvwc.edu">delaney_t@wvwc.edu</a></td>
<td>U.S.</td>
<td>No</td>
</tr>
<tr>
<td>WVVW Team Lead</td>
<td>Angela Meyer</td>
<td>(304) 550-0676</td>
<td>(304) 550-0676</td>
<td>Yes</td>
<td><a href="mailto:meyer_ak@wvwc.edu">meyer_ak@wvwc.edu</a></td>
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## Spaceflight Design Challenge - Exp Leads

Fall RS-X Team Availability Matrix

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Please use Mountain Time Zone times.
WORRIES | SYSTEM LEVEL

- Miscommunication as external component dimensions change in individual experiments
  - Can be solved with more detailed/regular communication between teams
- Miscommunication of the requirements to be matched by teams for effective operation as an entity of the payload
  - Send out a detailed User Guide over break defining design requirements (Covers all topics from PCB board dimensions to the location of the connector to the pinout requested of teams)
- Modification of pointing requirements will cause us to make the decision of sacrificing the objectives of individual experiments or make a massive revision to the layout of the payload deck/processing enclosure
WORRIES | INDIVIDUAL

HOBART AND WILLIAM SMITH COLLEGES
- Ensuring everything will operate when exposed to the extreme conditions
  - This will be mitigated through testing
  - This will also be mitigated once our payload’s “User Guide” is distributed

MARSHALL UNIVERSITY
- Properly configuring the encoder – Team member have not dealt with the encoders in the past

WEST VIRGINIA STATE UNIVERSITY (NO NEW UPDATES)
- Michelson Interferometer
  - Image stability is the biggest concern, which will be mitigated with a rigid structure for the camera, laser, mirrors, and beam splitter.
- Geiger-Muller Tubes
  - High voltage power supply for tubes may shift out of optimal range, so the circuit will be designed to prevent leaks.
- IMU / Solid state detectors
  - These units are internally complete, so the major risk is failing to make data connection.
WORRIES | INDIVIDUAL

SUBORBITAL REENTRY PAYLOAD

• Interior hardware stops working due to it experiencing unaccounted atmospheric conditions due to exterior structural integrity
• Capsule exterior experiences unaccounted excessive heat during reentry causing structural damage
• Continued fallback in schedule

WVWC: (No New Updates)

• Potential failures
  – Potential failures would mainly be around the solar thermionic converter
• Biggest worries: There are multiple worries with the solar thermionic converter.
  – Figuring out how to relieve pressure in the STC so that it does not burst without losing temperature
  – Figuring out how to insulate the STC with a material that can handle a rocket launch
  – Figuring out the best way to stabilize the STC so that the parabola does not change shape during the flight.
NASA’s Space Flight Design Challenge program is constantly expanding its RockSat initiative, creating a unique education opportunity for students. As we expand in the future, more students will be reached, fostering more innovative payload design.

- Working toward STR
  - All subsystems prototyped
  - Finalized Mechanical & Electrical Designs
  - Push objective for initial PCB designs for January Midpoint Review
  - Fallback date in mid February

- Questions
  - When do we receive the deck from you all?
BACKUP SLIDES
THEORY & CONCEPTS
• Crystals in the sensor generate a potential difference when they vibrate or are under mechanical stress.

• The Piezo Sensor will pick up the vibrations of the rocket throughout the flight with this potential difference.

• Two different metals are joined at one junction, hot junction, and separated at the other, the cold junction.

• The difference in temperature between the junctions creates a small voltage, related to the temperature.
Autonomous pointing and target acquisition will be achieved using the astronomy.net plate solution software engine to determine initial pointing of an alt-az mount, and thereby the required motion of the mount to reach the nearest target. Subsequent smaller-scale pointing corrections can be made in the same manner until the target is within an acceptable range of the image center.

Astronomy.net is a software engine that will do the plate solution for us. It will precisely calculate where we are looking. Then our program will be able to made a path for our servos to point at our target.

This experiment has been tested on RockSat-X in the past.

Resulted in an unsuccessful mission from shortage of time and issues with getting the mount fabricated.
MICHELSON INTERFEROMETER:
- Capable of measuring small displacements of light by detecting a change in interference patterns
  - A small change in the path of one beam causes a noticeable change in the interference pattern
- A laser beam is split in two and recombined again after reflections, creating characteristic interference pattern

GEIGER MULLER TUBES:
- Uses ionization effect of particles striking a low-pressure gas-filled Geiger-Muller tube to detect radiation
  - The effect is amplified by high voltage (400-600V) applied to the tube
THEORY AND CONCEPTS:

• Inertial Measurement Unit (IMU):
• 3-Axis accelerometer, measures linear acceleration on or by the probe
• Gyroscope tracks angular velocity of probe about each axis (Roll, Pitch, Yaw)
• Combination of sensor data, calculates the probes attitude, velocity and position

PAST EXPERIMENTAL INCREMENTS:

• A previous increment of the Suborbital Reentry Payload was flown on RSX-17
• Project successfully transmitted data back to the rocket
• Unfortunately, the data was garbled, due to carelessness during integration
• Failure could have been avoided with earlier testing
• SSD manufactured using Lithographic fabrication techniques
• Silicone detecting medium
• The absorption of ionizing radiation generates pairs of charge carriers in semiconducting material
  – Electrons and electron-deficient sites called holes
    • A hole is the name given to a missing electron in certain solids, semiconductors in particular
• The migration of carriers under influence of an applied voltage initiates a pulse of current. The pulses are amplified, recorded and analyzed to determine energy, number, identification of the incident-charged particles.
A thermionic converter consists of a hot electrode which emits electrons over a potential energy barrier to a cooler electrode, producing a useful electric power output. In other words, it is a hot conductor which allows a free moving particle carrying an electric charge over a barrier to a cooler conductor. This produces an electrical power output.

EXPECTED RESULTS:

• Data from the magnetometer should be close to NOAA values
• To learn of the feasibility and benefits of using a thermionic converter over solar panels in space.
PIEZO SENSOR:

1. Rocket enters small pockets of resistance
2. Pressure changes on the piezo sensor
3. Crystals on the piezo sensor vibrate
4. A small current is created on the piezo sensor
5. This current can be amplified and analyzed

TEMPERATURE PROBE:

1. Temperature readings will begin T-3 before takeoff
2. The rocket travels through different layer of the atmosphere
3. A temperature difference is created between the hot and cold junction
4. A voltage is created.
The temperature probe and the piezo sensor are both going to be connected to the Arduino.

The data is going to be saved in the SD card that is connected to the Arduino and sent to ground, via the DAQ board provided by the payload.

The experiment will interface with the DAQ through UART at 57600 baud.

The software for the experiment will be written in Arduino’s native language.

The Arduino is going to be receiving 5 V from the payload’s power distribution system (PDS).

PAYLOAD LAYOUT:
- Everything except the temperature probe will be housed in the processing enclosure on a 3” x 4” x 1” PCB.
The Pi is the brain and will perform all the calculations using our program and astronomy.net. Depending on where it is in the program it will send a signal to the motor controller to move the motors which aim the camera. The encoders will ensure we have an accurate positioning of the camera. When in position there will be a signal given by the pi to take a picture. It will take this picture and use astronomy.net to calculate where it is pointing. Once calculated it will move the camera so it is pointing toward one of our target stars, then take another picture of the target.

Current design uses an Alt/Az mount whose motion is determined through the astronomy.net plate solution. To do this we will use two motors connected together to move a camera so it is pointed at a target star. All of this will be controlled by a Raspberry Pi zero that will be programmed using python language.

We attempted this mission last year and had issues getting everything together, this year we have revamped all the brackets and are using a different camera that will work better with our program.
WVSU: DESIGN OVERVIEW

- Geiger counters — Geiger-Muller tubes, Electric circuits converting to high voltage, Microcontroller(s)
- Solid state radiation detectors
- IMU
- Michelson Interferometer — Raspberry Pi, Camera, Beam-splitter, Lens, Mirrors (2), Laser 650nm 5mW

- Raspberry Pi will use a Raspberry Pi Camera Module to capture interference patterns generated by the Michelson Interferometer.
- Four Geiger tubes will each have a separate high voltage circuit and use a microcontroller to detect and record radiation pulses.
- A central microcontroller will collect data from the Geiger tubes, three silicone detectors, and Raspberry Pi to store data on an SD card and transmit over telemetry at 57,600 baud rate.
WVU-SRP: DESIGN OVERVIEW

- Resistance Temperature Detector (RTD): Resistor that increases in value with temperature
- Inertial Measurement Unit (IMU): Collects angular acceleration and linear velocity
- Electromagnetic Launch System: Pushes the capsule out of the payload
- Launch Mechanism will be pressure activated
- Capsule will be thermally insulated to keep all the interior components from freezing/overheating
- IMU will be included in the probe to measure altitude, velocity, acceleration and position
- Microcontroller will be in the probe to package and transmit data
• The signal output by the detector (before the analog conditioning circuitry) is depicted by the dark blue graph
  • Small Amplitude (range of a few mV)
  • Fast rise time (Pulses “ride up” on one another)
  • Cannot be digitized

• The signal after conditioning is seen in the cyan graph.
  • 3.2 μs time constant prevents pulses from “riding up”
  • Signal experiences a configurable voltage gain
  • Can be digitized
SCIENTIFIC DESIGN:

• Magnetometer—Record the magnitude and direction of Earth’s magnetic field.
• Solar Panel—Receive light from the sun and convert to a voltage.
• Solar thermionic converter—receive light from the sun that will bounce off a mirrored surface and onto a metal (parabola shaped).
• Thermocouple—Receive temperature from reflector system and convert to a voltage.
• Arduino Pro Micro—receive data from magnetometer, solar panel, and reflector system.
• Openlog—stores our data.

ENGINEERING DESIGN:

• Solar panel and thermionic converter will be outside the enclosure. The rest of the PCB will be inside the enclosure.
• The location of the solar panel and thermionic converter is imperative for a successful experiment.
• The experiment will receive 5 V @ 700 mA from the PDS. All data from the experiment will be stored locally in a microSD.
• Software for the Thermocouple will be heritage from previous missions.
EXPECTED RESULTS
HWS: EXPECTED RESULTS

VIBRATION:
• Larges range of frequencies throughout the flight
• Vibrations will occur due to different pockets of molecules in the atmosphere
• Largest range of frequencies will occur perpendicular to the rocket

TEMPERATURE:
• Range: -100°C to 500°C
• Highest temperature during reentry
• The rocket will endure a lot of friction during reentry
• This mission is a flight test / proof-of-concept experiment for an autonomous pointing determination and target acquisition system for astronomical instruments. A successful test will consist of:

  – Determination of initial pointing from image data.
  – Successful slew to nearest target.
  – Obtaining image of the chosen target.
  – Time permitting, acquisition and imaging of additional targets
WVSU: EXPECTED RESULTS

- GEIGER COUNTER/PARTICLE DETECTORS – From previous missions, radiation varied between 0 and 300 cps

- MICHELSON INTERFEROMETER – Interference picture, captured by camera

- IMU – Acceleration between 0 and 250 m/s\(^2\), rotation rates between 0 and 5 Hz, and magnetic fields between 0 and 70 \(\mu\)T
WVU-SRP: EXPECTED RESULTS

- Expect the launching mechanism to launch the probe at the desired altitude under the given atmospheric conditions without causing any structural damage to the probe or capsule.
- Expect the capsule to remain intact during flight and expect it to re-enter into Earth's atmosphere intact without any major damage to the exterior or interior hardware.
- IMU – expect the acceleration to be between 0 and 300 m/s².
- RTD -- expect the exterior temperature to experience temperatures exceeding 500 °F.
• If a temperature sensor rated in the expected temperature range is not found, there are companies that create custom made ones.

• If a piezo sensor rated in the expected frequency range is not found, there are companies that create custom made ones.
• If we run into machining issue, we can 3D print our brackets.

• We also now have a machinist on staff capable of making parts for us.

• If we have any issues with availability and lead time with motors or the camera there are many different suppliers we can contact and get one close enough that should work. We also have similar cameras we can integrate.
• If the telemetry is not reliable, data can still be stored on a SD card.
• If software does interpret images accurately, a video will be stored on the SD card.
• If not all of the Geiger-Muller tubes fit, we can change the number or selection of tubes to use.
• If the precision mirror mounts are too expensive, we can 3D print mounts.
If we can’t send data wirelessly, a Waveshare GPS module will take its place

If specific parts of the launcher cannot be machined in time, they can be 3D printed
• A servo drives a rotating “door” to prevent the PS assembly from being damaged by reentry temperatures or splashdown.

• The door must remain open throughout the mission and close before GSE is turned off.

• The door is a potential off-ramp if problems are found during sequence tests.
  – Would have to have high confidence that the experiment would work as the PS assembly would be trashed.
• In case of shortage of time, only needed tests can be performed on the solar thermionic converter.
• In case of difficulty with solar thermionic converter, the areas of the solar panel and STC can be different.
• In case of budget limitation, fewer materials could be bought for testing.