WV-SPACE
Full Mission Simulation Review

WVU MU FSU BRCTC WVU-TECH BVCTC SU
WVWC WVSU NASA IV&V

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3/30/2016
Presentation Outline

• Section 1: Mission Overview
• Section 2: Subsystem Status & Testing Results
  – 2.0a: WVU-CI
  – 2.0b: WVU-LP
  – 2.0c: MU-SPACE
  – 2.0d: WVSU-SPACE
  – 2.0e: WVUT-SPACE
  – 2.0f: BVCTC-SPACE
  – 2.0g: BRCTC-SPACE
  – 2.0h: FSU-SPACE
  – 2.0i: WVWC-SPACE
• Section 3: Full Mission Simulation Results
• Section 4: Project Management Update
1.0 Mission Overview
WV RSC’16 Mission Overview

• Goal: Develop and test several science and engineering experiments for space operations

• Objectives:
  – Capture NIR Earth images from space
  – Measure plasma density in upper atmosphere
  – Measure atmospheric pressure and magnetic field of Earth
  – Gather redundant flight dynamics data
  – Determine attitude in space relative to sun
  – Strain on PCB during launch

• Port Access: Optics port (1) and Multipurpose port (2)

• Benefits SmallSat community
  – Develop COTS orientation estimation techniques
  – Develop low-cost Langmuir probe package for plasma studies
  – Prove feasibility of 3D printed structural elements
Concept of Operations

- **Launch**
  - $H = 0 \text{ km} \ (T = 0)$

- **End of Orion Burn**
  - $H = 52 \text{ km} \ (T = 0.6 \text{ min})$
  - **Boom extension triggered**

- **Apogee**
  - $H = 115 \text{ km} \ (T = 2.8 \text{ min})$

- **Chute deploys**
  - $H = 10.5 \text{ km} \ (T = 5.5 \text{ min})$

- **Boom retraction triggered**
  - $H = 50 \text{ km} \ (T = 4.5 \text{ min})$

- **Splashdown**
  - $H = 50 \text{ km} \ (T = 15 \text{ min})$

- **All systems on**
  - $H = 0 \text{ km} \ (T = -3 \text{ min})$
  - **Begin data acquisition**

- **End of Orion Burn**
  - $H = 0 \text{ km} \ (T = 15 \text{ min})$

- **End of Orion Burn**
  - $H = 0 \text{ km} \ (T = 15 \text{ min})$

- **End of Orion Burn**
  - $H = 0 \text{ km} \ (T = 15 \text{ min})$

- **End of Orion Burn**
  - $H = 0 \text{ km} \ (T = 15 \text{ min})$

- **End of Orion Burn**
  - $H = 0 \text{ km} \ (T = 15 \text{ min})$
2.0a Subsystem Status
WVU-CI
Integrated Subsystem Testing Status

• DITL results
  – Run through flight code for full duration (approx. 20 min)
  – Data collection is verified (working on it)
  – DITL results incomplete
    • Recent completion of WVU-CI
    • Solar panel redesign

• Follow up testing
  – Vibration testing will confirm mission operations under flight conditions

75%
Full Mission Simulation Results

- **Linear actuator positioning**
  - Maximum radius of 5.75” when deployed
  - 1.5” offset from center

- **NDVI field testing**
  - Captured images of vegetation for NDVI analysis
  - Discovered issue with reboot when powered off while running flight code
2.0b Subsystem Status
WVU-LP
Integrated Subsystem Testing Status

• LP-DAQ board fully populated and tested
• MicroSD card based data storage using SPI is working great
• MP-Sensor board is populated w/ exception of (I-V) amp
  – Testing the differential driver before adding to I-V amp to see how much voltage offset it is going to contribute
  – Measurement has been completed
  – I-V amp installing to occur this week
WVU-LP Testing

• Quick Status:
  – Communication w/ ADC
    • Working to improve consistency of data
    • Adjusting clock rate to find sweet spot between sample rate and consistency
  – Communication w/ DAC
    • Working to increase the frequency of sweeping bias voltage
    • Currently maxing out at ~260Hz
    • Goal is 1KHz
2.0c Subsystem Status
MU-SPACE
Integrated Subsystem Testing Status

- Power, Data Collection, and Storage

75%
Integrated Subsystem Testing Status: Solar Panel

2.0 Solar Panel

• The PCB has been assembled, and an early prototype of the solar panel board with the solar cells has been tested.
  • The electric connections between the cells and the prototype board function as expected
  • Because the conductive epoxy was more difficult to work with than expected, and because the cells are extremely fragile, decided to work with a different epoxy formulation and a syringe dispenser to make delivery more precise
  • Solar panel spec sheet was off, so tips overhang – redesigned solar panel pedestals
  • Panel board has been prepped and assembled for testing
MU-SPACE Testing

• Main board functions have been tested and perform as expected
  – Data values can be recorded at the needed cadence
  – Communications between the Pi and the sensor components work as expected

• Solar cells have been tested with a prototype board
  – Electrical connections between the cells and prototype board work well

• Action Items left between now and LRR:
  – Affix solar cells to solar panel in a final configuration
  – Verify connections with the current sensing circuits
  – Calibrate current levels for maximum lighting
2.0d Subsystem Status
WVSU-SPACE
Integrated Subsystem Testing Status

State-1 PCB fully assembled

Payload integrity testing complete

IMU accelerometer calibration in progress

IMU magnetometer calibration in progress

Resolving multiple ionization issues with Geiger counter
WVSU-SPACE Testing

• **Quick Status:**
  - Multiple ionization issue to be resolved by May 30
  - Payload integrated and functional
  - Useful, representative data recorded
  - Working on algorithms to analyze data
2.0e Subsystem Status
WVUT-SPACE
Integrated Subsystem Testing Status:

Mechanical Design + Electrical Design

The electrical design in ExpressPCB will show how the mechanical design needs to be setup

Test was completed on May 7\textsuperscript{th} with only some minor problems

More of the design process will be completed through the month of May
Full Mission Simulation Results

Testing Overview:

– Only problem found was integration of ADIS16305 IMU (an incorrect connector footprint was used)
– Sensors integrated onto board PCB
– Final testing needs to be done on the SD card in order to store all the in-flight data
– All coding needs to be implemented into a single block of code instead of in individual blocks for each sensor.
2.0f Subsystem Status
BVCTC-SPACE
Integrated Subsystem Testing Status:

Data Collection

All sensors successfully tested individually

Testing together ongoing; small hang-up with bitrates
BVCTC-SPACE Testing

• Remaining Items:
  – Mechanical integration of sensors/Arduino into housing
  – Inclusion of power/USB connectors into housing
  – Plan to complete final fabrication by end of week
    – Lead time for 3D printing has been the main time constraint
2.0g Subsystem Status
BRCTC-SPACE
Integrated Subsystem Testing Status

Fully Integrated Payload

PCB has been populated and Voltage Boost Circuit runs properly

All components have been integrated

All devices are functioning properly with expected data acquisition
Full Mission Simulation Results

- All that is left is cleaning up code to be more organized and soldering final parts on to the PCB.

- Test results are comparable to all previous tests
2.0h Subsystem Status
FSU-SPACE
Integrated Subsystem Testing Status

This shows the output to the SD card and how all the components have been integrated successfully with each other.

The only thing left for full integration would be having a voltage regulator.

The goal is to have the voltage regulator built into the PCB when we design it.

In the picture below, everything is working together the same time, and giving correct measurements.

Results on the right came from this set up.
3.0 Full Mission Simulation Results

- New PCB received and fully populated
  - Issue with gyro not receiving correct voltage
  - Scheduled a meeting today to either fix or off-ramp the sensor
2.0i Subsystem Status
WVWC-SPACE
Integrated Subsystem Testing Status:

PCB Assembly

- Created on ExpressPCB
- Results:
  - Good: board works without failures and LED lights are very helpful (used to see if units are turned on and working).
  - Bad: Arduino Pro Micro has bad placement (not able to plug in cord because of OpenLog in the way) and should have used short header pins.
Full Mission Simulation Results

Shake Test

- Done twice, once with power to the PCB and once without.
- Extended to around 15-30 seconds.
- All components stayed intact and operational
3.0 Full Mission Simulation Results
Canister Integration

RockSat-C 2016

FMSR

35
Vibration Testing

• ATK Vibe testing – 6/2
  • Verify structural design is adequate
  • Identify design flaws & weak points
• Wallops Vibe testing – 6/18
  – Verify any design alterations
  – Provide final confirmation of structural integrity
System Level Testing

• Final fit check complete
  – Still need to position VID cameras in optimal positions

• Major hurdles:
  – Late PCB orders caused delays in canister integration and testing
  – Will have full simulation test run by 5/31
  – Check-in procedure run-through 6/2
4.0 Project Management Update
Action Items

• Finish PCB assemblies and final integrated testing
• Finalize positioning and mounting of VID cams
• Wiring and harness routing
• Ballast placement
• Check-in procedures
• ATK vibe test prep
<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>With 1’</td>
</tr>
<tr>
<td>Contained in can</td>
<td></td>
</tr>
<tr>
<td>Connected to can by 4/5 bulkheads on top and bottom only</td>
<td></td>
</tr>
<tr>
<td>Mass at 20±0.2lbs (full can)</td>
<td>Currently 20 lbs with ballast for 0.2lb tolerance</td>
</tr>
<tr>
<td>Shared canister clearance</td>
<td>N/A</td>
</tr>
<tr>
<td>No voltage on the can</td>
<td>No opportunity to check yet</td>
</tr>
<tr>
<td>Activation wires at least 4 ft</td>
<td></td>
</tr>
<tr>
<td>Activation wire at least 24 gauge</td>
<td>22 gauge</td>
</tr>
<tr>
<td>Early Activation: current &lt; 1 A</td>
<td>No opportunity to check fully integrated current draw yet</td>
</tr>
<tr>
<td>T-0 Activation: current &lt; .1 A</td>
<td>Not using</td>
</tr>
<tr>
<td>Battery Type</td>
<td>Li-Po (will not charge at Wallops)</td>
</tr>
</tbody>
</table>
Biggest Worries

• MU-SPACE solar panels are very brittle
  – Conformal coating will help
• Last minute PCB assemblies for some schools
  – Using spare PCBs as placeholders for missing experiments
• Mid section is VERY tight!
  – Could cause issues with pin connections
Conclusions

• Will be fully integrated by end of May
  – Check-in procedures performed thereafter
• Vibrations testing will prove flight worthiness
  – Test like you fly!
• What a learning experience for all!!
Appendix

- System Level Block Diagrams
- Functional Block Diagrams
- Electrical Schematics
- Mechanical Designs
- Software Designs
- Mechanical Model
- Mass Budget
- Hazardous Mechanical Items
- Power Budget
- Hazardous Electrical Items
- Descopes & Off-ramps
WVU-CI: Functional Block Diagram

- Raspberry Pi (SBC) 5V
- 16 GB MicroSD Card
- Mini Web Camera (Payload Camera)
- Pi-NIR Camera (NIR Cam)
- Pi-Camera (RGB Cam)
- Linear Actuator (NIR Boom) 7.4 V
- Digital I/O
- Ribbon
- Power Data
- PDS (x2 LiPo 7.4V 5Ah)
- T-3 Mins Early Activation (Wallops)
WVU-CI: Electrical Schematic (SBC)
WVU-CI Mechanical Design
**WVU-CI: Software Design Elements**

**Server CPU**
- **Start**
  - **Send Command**
    - **Check for Acknowledgement**
      - **NO**
      - **Acknowledgement received?**
        - NO
  - **NO**
    - **Time Expired?**
      - NO
      - **End**

**Client CPU**
- **Start**
  - **Check for command**
    - NO
    - **Command received?**
      - NO
      - **End**
  - **Send Acknowledgement**
    - **Capture Image**
      - **Store Image**
        - Time > 1.3 min (80 sec)
        - **Extend Boom**
          - Time > 4.5 min (270 sec)
          - **Retract Boom**
            - Time Expired?

*RockSat-C 2016*
WVU-CI Mechanical Elements

• To be manufactured:
  – Mackrolon plates
  – 3D printed camera and actuator mounts

• To be procured:
  – Payload cameras
  – ABS plastic material
  – Structural materials

• Procure remaining components: 1/18/2016

• Camera mounts fabricated: 2/22/2016

• Subsystem integration: 2/29/2016
WVU-CI Electrical Elements

• No electronics manufacturing required
• COTS single board computer for main PCB
• To be fabricated/procured:
  – Power leads for Raspberry Pies
  – Extended ribbon cables for cameras
WVU-CI Software Elements

• Camera configuration
  – Configure frame rate and image quality

• Video capture
  – Single command to capture continuous video file until power interrupted
  – Incorporate server/client communication
  – Use current date/time to write new file names

• Audio capture
  – Single command to capture continuous video file until power interrupted
  – Use current date/time to write new file names

• Camera software testing: 1/18/16 – 3/10/16
WVU-LP Functional Block Diagram

Data Acquisition Board

- NetBurner µController: TTL Serial 115,200 baud
- OpenLog Data Logger
- SPI3 20MHz
- SPI0 40MHz
- DAC, Analog conditioning
- ADC, Analog conditioning

Local Voltage Regulation:
- 3.3V, 5V, +/-12V

I-V amplifier Board

- Analog -2V to 6V
- Transimpedance amp
- Diff. buffer
- Local Voltage Regulation: +/-12V

Battery and Power Distribution Board

- 11.1V (raw battery voltage)
- Enable, GND
- WFF Early Activation Relay

WFF Early Activation Relay
WVU-LP Mechanical Design

Langmuir Probe – RockSat-C 2014

3D Printed “Mock-up” Multipurpose Port

LP: 4” Stainless Steel Rod (3” uninsulated length), 1/8” Diameter
WVU-LP Mechanical Design (Cont)
WVU-LP Software Block Diagram

1. Read DAC value from table
2. Send value to DAC and buffer
3. Sample ADC and send value to buffer
4. Write buffer to OpenLog

Table contains 292 voltage steps
1KHz sweep/sample rate

Table contains 292 voltage steps
value from table – 292 values
MU-SPACE Functional Block Diagram

Legend:
- Blue: Data/Control
- Red: Power

- AdaFruit 10DOF IMU
- Real Time Clock
- Raspberry Pi 2 Model B
- Micro SD Card
- Data/Control: Panels
- Power: Current Amplifier
- Power: Pro Micro ADC
MU-SPACE Mechanical Design

- We just got our equipment and are finalizing the mechanical design
MU-SPACE Electrical Design
MU-SPACE Mechanical Elements

• The Raspberry Pi2 Model B, IMU, data logger, microSD card, current sensor, and RTC have all been purchased.
• Have not purchased the solar cells yet that are ultimately going to fly
• The mount for the solar cells still needs to be 3D printed
WVSU-SPACE Functional Block Diagram

LND 713 Geiger
3.7 V

Adafruit
IMU
3.7 V

Openlog (SD Card)

Arduino Pro Mini
3.7 V

T-3 switch

Power Distribution System

Anode
Cathode

Ground
Live
WVSU-SPACE Electrical Schematic

- Design features 400V 250 micro ampere power supply
WVSU-SPACE Mechanical Design

- Metal GM tube contains gas and may have loose parts if broken
WVSU-SPACE Software Design

Import Libraries
Declare Variables

Setup
Begin Serial Communication
Initialize pins
Start Countdown

Loop
Timer Zero
Radiation Detected
Acceleration Detected

End Loop
+1 Counter
Send Value to Sr. Monitor

NO
NO
Skip Block

YES
YES
YES

NO
NO
WVSU-SPACE Mechanical Elements

• IMU and data collection components received, soldered & prototyped
• Geiger counter components yet to be received.
WVSU-SPACE Electrical Elements

- IMU and Data Logging Subsystems Manufactured. Pins soldered.
- Geiger Counter Yet to be Soldered. PCB soldering pending board arrival
- PCB drafted. Final after GC assembly
- Voltage regulator and timer circuit in house
- PCB yet to be procured
WVSU-SPACE Software Elements

- IMU Code Complete, Working and Tested
- Code free data logging
SU-SPACE Functional Block Diagram

- ADIS, Adafruit, Razor and TMP102 used to take and compare data
- Open log for storing data
SU-SPACE Electrical Design
SU-SPACE Mechanical Design

- Size of board is 4x4 as required
- Total height of payload is 1.088 in
SU-SPACE Software Design

Pro Micro 1

Start

Increment Time

Get Adafruit Readings

Get Razor Readings

Did Razor send data?

Is this attempt # > 5?

Did it send data?

Did 1 second pass?

Get data from Pro Micro 2

Is this attempt # > 5?

Log all data to Openlog

Set pinmodes

Set Serial and Software Serial

Start Writing to Openlog
SU-SPACE Software Design (cont)

• Start both pro micros by setting everything up (meaning assigning pins, starting serial, etc.)
• Then data collection begins (Razor, Adafruit and Openlog on Pro Micro 1; ADIS and tmp102 on Pro Micro 2)
• Send data from Pro Micro 2 to Pro Micro 1
• Last, store data in Openlog
• Repeat data collection and storage
WVUT-SPACE Functional Block Diagram

- Microcontroller Arduino MINI (3.3V)
- Flash Memory (SD Card) (3.3V)
- Power Distribution System (3.7V)
- T-3 Early Activation Switch

Components:
- Adafruit IMU Sensor
  - 3D Gyroscope
  - 3D Magnetometer
  - 3D Accelerometer (3.3V)
- Strain Gauge
- Disc TAS606 (1V)
- ADC
WVUT-SPACE Mechanical Design:

Sample Circuit Board Design Without Strain Gauge
WVUT-SPACE Software Block Diagram

- Arduino Sample Code for Microcontroller (Work in Progress)
- Accelerometer, Magnetometer, Gyroscope Sample Code (Being Tested)
- SD Memory Coding (To Do)
- Strain Gauge Sample Code (Being Written)
• One major subsystem related to data gathering and storage
• Consists of all displayed sensors & data logger
1 arduino mini
2 Magnatometers
3 ADIS16305 IMU
• First housing prototypes printed for comparison testing
• Software relatively simplistic; snapshots of sensor readouts every interval
BRCTC-SPACE PCB Design

4X 4.06mm Via with 3.18mm Thru Hole to be left open for No. 4 Pan Head Screw and washer mounting hardware to pass thru to the PCB mounting plate

4X 4.06mm Via with 3.18mm hole for No.2 Press Nuts

13 X 6.00mm Via with 4.24mm hole for No.4 Press Nuts
BRCTC-SPACE Mechanical Design (Cont)
BRCTC-SPACE Mechanical Design (Cont)
BRCTC-SPACE Software Design
FSU-SPACE Functional Block Diagram
FSU PCB Design
We have decided how to arrange all the components during flight and on our PCB; which we have represented using Inventor Professional 2016.
FSU-SPACE Software Design

1. Initialize Program
2. Create OpenLog File
3. Take Reading From ADXL377
   - If Reading <= 3g
     - ADIS16305
   - If Reading > 3g <= 24g
     - LIS331
   - If Reading > 24g
     - ADXL277

   - Take Reading from ADIS16305 Gyrometer
   - Take Reading from Honeywell HMC2003 Magnetic Sensor

   - Store Acquired Data to OpenLog
WVWC-SPACE Function Block Diagram

Design: circuit board (4 in x 4 in)
Mounted to circuit board:
  • Razor inertial measurement unit
  • Arduino Pro Micro microprocessor
  • OpenLog flash memory
  • Power connectors, regulators, and boost

3.7 volts unregulated supply
Will be regulated to 3.3 v
Will be boosted to 5v for Arduino

External power supply for motor
5 volt, 2 amp
Electrical Design:

- The Arduino Pro Micro has only one dedicated hardware serial interface

- One of the devices will use the hardware serial and the other device will use software serial through assigned digital pins
WVWC Flight System Diagram

Electrical

- Only flight portion of system
- Motor apparatus not shown
**WVWC-SPACE Mechanical Design**

- **IMU, Microprocessor, SD card, Power**
  - “flying” portion of mechanical design
  - No hazardous materials present

  **IMU**
  - \( L = 3.49 \text{cm} \)
  - \( W = 1.82 \text{cm} \)
  - \( H = 0.6 \text{cm} \)

  **Arduino**
  - \( L = 2.9 \text{cm} \)
  - \( W = 4.1 \text{cm} \)
  - \( H = 1 \text{cm} \)

  **SD Card**
  - \( L = 2.07 \text{cm} \)
  - \( W = 1.6 \text{cm} \)
  - \( H = 0.55 \text{cm} \)

  **Power**
  - Includes power connector, power regulator, and 5v boost converter
  - \( L = 5 \text{ cm} \), \( W = 4 \text{ cm} \), \( H = 2 \text{ cm} \)

  **4in x 4in board**
WVWC Mechanical Design (Cont)

- Mechanical/Structure
  - New measurements in red circle.
Circuit Board

Top and bottom of board:
- Red is on top
  - Power
  - TX and RX (Razor and Arduino)
- Green is below
  - Ground
  - RX (OpenLog)
  - D4 (Arduino)
Read rotation rate around z-axis of gyro

Calculate an output voltage proportional to the rotation rate

The sign on the rotation rate gives the direction of rotation

The output voltage and spin direction would be used to spin a motor that would counteract the vehicle motion

Since we are not flying the motor part of the experiment, the gyro data and the “response” data will be written to flash memory

Software Flow Diagram
Mechanical Model: Isometric Front
Mechanical Model: Isometric Back
## Detailed Mass Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Component</th>
<th>Total Mass (lbf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WVWC-SPACE</td>
<td>PCB</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Sensors/DAQ</td>
<td>0.04</td>
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<tr>
<td>WVUTech-SPACE</td>
<td>PCB</td>
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<td></td>
<td>Sensors/DAQ</td>
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<tr>
<td>Marshall-SPACE</td>
<td>PCB</td>
<td>0.1</td>
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<tr>
<td></td>
<td>Sensors/DAQ</td>
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<tr>
<td>Shepherd-SPACE</td>
<td>PCB</td>
<td>0.1</td>
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<td></td>
<td>Sensors/DAQ</td>
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<tr>
<td>WVSU-SPACE</td>
<td>PCB</td>
<td>0.05</td>
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<td>Sensors/DAQ</td>
<td>0.05</td>
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<td>FSU-SPACE</td>
<td>PCB</td>
<td>0.1</td>
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<td></td>
<td>Sensors/DAQ</td>
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<td>BRCTC-SPACE</td>
<td>PCB/Housing</td>
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<tr>
<td></td>
<td>Sensors/DAQ</td>
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<td>BVCTC-SPACE</td>
<td>PCB</td>
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<td>Sensors/DAQ</td>
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### WV-SPACE

<table>
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<tr>
<th>Subsystem</th>
<th>Component</th>
<th>Total Mass (lbf)</th>
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<tbody>
<tr>
<td>WVU-CL</td>
<td>Sensors</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>Single Board Computer</td>
<td>0.3</td>
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<tr>
<td></td>
<td>Actuator</td>
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<tr>
<td>WVU-LP</td>
<td>PCB</td>
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<td></td>
<td>Probe</td>
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<td>Sensors/DAQ</td>
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<td>PDS</td>
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<td>Mounting Brackets</td>
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<tr>
<td></td>
<td>Ballast</td>
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<tr>
<td></td>
<td>Canister</td>
<td>Full Can</td>
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</tbody>
</table>

**Target Weight (lbf) 20**

**Total 20**

**Over(+)/Under(-) 0**
Hazardous Mechanical Items

- WVU-CI linear actuator
  - Hazard mitigation plan to mount actuator such that the physical limits do not exceed hazard area (optics port)
- 3” Langmuir probe
  - Rod protruding 3” will be covered with rigid foam block at all times during integration
- 3D Printed Materials
  - FEA to ensure strength & rigidity in design
  - Vibe testing for confirmation
# Power Budget

**WV Rocketeers - RSC2015 Power Budget**

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Voltage (V)</th>
<th>Max Current (A)</th>
<th>Time On (min)</th>
<th>Watts</th>
<th>Ah</th>
</tr>
</thead>
<tbody>
<tr>
<td>WVWC-SPACE</td>
<td>3.7</td>
<td>0.03</td>
<td>30</td>
<td>0.10</td>
<td>0.01</td>
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<tr>
<td>WVUT-SPACE</td>
<td>3.7</td>
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<td>0.47</td>
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<td>MU-SPACE</td>
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<td>0.35</td>
<td>0.05</td>
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<td>FSU-SPACE</td>
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<td>0.37</td>
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<tr>
<td>BRCTC-SPACE</td>
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<td>0.39</td>
<td>0.05</td>
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<tr>
<td>BVCTC-SPACE</td>
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<td>0.52</td>
<td>0.07</td>
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<td>WVU-CI</td>
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<td>0.60</td>
<td>3</td>
<td>4.44</td>
<td>0.03</td>
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<td>5.92</td>
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<tr>
<td><strong>Total Power Capacity</strong></td>
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<td></td>
<td></td>
<td>16.07</td>
<td>2.15</td>
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<tr>
<td><strong>Over (+)/Under (-)</strong></td>
<td></td>
<td></td>
<td></td>
<td>7.86</td>
<td>10.00</td>
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<tr>
<td><strong># of Flights Margin</strong></td>
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<td></td>
<td></td>
<td>4.7</td>
</tr>
</tbody>
</table>
Hazardous Electrical Items:

- **PDS LiPo batteries**
  - Will not charge at wallops
  - Using fresh batteries for launch

- **WVSU-SPACE Geiger counter high voltage regulator**
  - Taking precautions to guard high voltage area from touch
  - Keep away labeling around the high voltage supply
Descopes/Off-ramps

- WVU-CAM
  - Off-ramp if necessary
    - Audio Data collection from built in microphones on payload cameras
    - Include a rigid mount for NIR lens instead of including the linear actuator
  - Impact
    - No audio data to accompany video indication data
    - Cause image degradations with the NIR imaging experiment
- FSU-SPACE
  - Off-ramp if necessary
    - Barometric/Temperature sensor with BRCTC
  - No impact on objectives
- BVCTC-SPACE
  - Off-ramp if necessary
    - Use Arduino pro-mini microcontroller instead of Parallax Propeller ASC+
- WVUTech-SPACE
  - Descope
    - No longer including tensile apparatus for ABS strain experiment
    - Working with BVCTC to place strain gauge on their ABS container
  - Impact
    - No longer get yield stress data on ABS plastic in space
  - Off-ramp if necessary
    - Strain gauge experiment all together to focus on flight dynamics
Descopes/Off-ramps (Cont)

- **BVCTC-SPACE**
  - Off-ramp if necessary
    - Redundant sensors
    - 3D printed case
  - Impact
    - No cost vs. performance comparison on COTS IMUs and magnetometers

- **WVWC-SPACE**
  - Off-ramp if necessary
    - Only use one inertial measurement unit
    - Only use gyroscope information from the inertial measurement unit
    - Only measure and respond to one degree of rotational freedom
  - No impact on objectives

- **WVState-SPACE**
  - Off-ramp if necessary
    - Use Micro-Geiger kit instead of building from scratch using LND 713 tube
  - No impact on objectives

- **SU-SPACE**
  - Off-ramp if necessary
    - To use NCP1402 voltage regulator in place of designing our own
    - To use iSensor board with ADIS instead of working proper connections into custom PCB design
  - No impact on objectives
Schedule

• Major Milestones
  • CDR (12/8/2015)
  • Prototype high risk items (12/20/2015)
  • Flight award announcement (1/16/2016)
  • Procure remaining components (1/18/2016)
  • Design PCBs (Week of 3/1/2016)
  • STR (Week of 2/22/2016)
  • ISTR (Week of 3/28/2016)
  • Receive canister (Week of 4/11/2016)
  • Assemble PCBs (Week of 5/4/2016)
  • FMSR (Week of 5/23/2016)
  • Vibration & atmospheric chamber testing (Week of 5/30/2016)
  • Deliver preliminary check-in document (Week before 6/6/2016)
  • LRR (Week of 6/6/2016)
  • Travel to Wallops (6/16/2016)
  • Launch (6/23/16)*
    – * Tentative, no guarantee – small chance launch could get cancelled due to weather or other unforeseen delays
Design Overview: Shared Can Logistics

• Partners (NASA IV&V Sponsored):
  • West Virginia University Team: WVU-CAM
  • West Virginia Wesleyan College: WVWC-SPACE
  • Shepherd University: SU-SPACE
  • Marshall University: MU-SPACE
  • West Virginia University Institute of Technology: WVUTech-SPACE
  • Fairmont State University: FSU-SPACE
  • Bridge Valley Community Technical College: BVCTC-SPACE
  • Blue Bridge Community Technical College: BRCTC-SPACE
  • West Virginia State University: WVSU-SPACE
Design Overview: Shared (Logistics)

- Plan for collaboration:
  - Weekly/Monthly Telecon sessions
  - Share designs using Google drive
  - Will fit check before June
- Mounting to both bottom and top bulkheads of canister.
- Structural interfacing:
  - Aluminum standoffs
- Not using a mid-mounting plate
- Ports:
  - Optical (WVU & MU)
  - Multipurpose (FSU & BRCTC)
# Budget

<table>
<thead>
<tr>
<th>Item</th>
<th>Supplier</th>
<th>Estimated, Specific Cost</th>
<th>Number Required</th>
<th>Total Cost</th>
<th>Notes</th>
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</thead>
<tbody>
<tr>
<td>Devices</td>
<td>Various</td>
<td>$980.00</td>
<td>9</td>
<td>$8,820.00</td>
<td>9 experiments kept under $1k each</td>
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<tr>
<td>PCBs</td>
<td>Advanced Circuits</td>
<td>$270.00</td>
<td>9</td>
<td>$2,430.00</td>
<td>9 subsystems require custom PCBs, expect 2 revisions each</td>
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<tr>
<td>Electronic Components</td>
<td>Digi-Key</td>
<td>$150.00</td>
<td>9</td>
<td>$1,350.00</td>
<td>1 set of components per 9 PCBs</td>
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<td>Structural Supplies</td>
<td>McMaster-Carr</td>
<td>$300.00</td>
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<td>$300.00</td>
<td>Only need 1 set of mechanical parts</td>
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<td>Lab Supplies</td>
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<td>$630.00</td>
<td>Allowance for lab supplies for each team</td>
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Total (no margin): $13,530.00

Total (w/ margin): $16,912.50