West Virginia Space Flight Design Challenge
Integrated Subsystems Test Review (ISTR)

West Virginia State University (WVSU)
West Virginia Wesleyan College (WVWC)
Blue Ride Community and Technical College (BRCTC)
West Virginia University (WVU)
March 16, 2020
Presentation Outline

• Team By Team:
  1. Entire System (WVSFDC)
  2. West Virginia State University (WVSU) Experiment
  3. West Virginia Wesleyan College (WVWC) Experiment
  4. Blue Ridge Community and Technical College (BRCTC) Experiment
  5. West Virginia University (WVU) Experiment
     • Section 1: Mission Concept and Interfaces
     • Section 2: Design Overview
     • Section 3: Subsystem Testing Status
     • Section 4: Integrated Subsystem Testing Status
     • Section 5: Plan for FMSR
     • Section 6: Project Schedule
     • Section 7: Project Management
     • Section 8: Conclusion
1.0.0 WVSFDC Overview

Adam Kobelski
Greg Lusk
Clayton Cobb
1.1.0 Mission Concept and Interfaces
Mission Overview

• The WV SFDC uses four independent experiments to provide access to space for WV students. This opportunity allows participants to gain valuable STEM skills and experience while also building infrastructure for future in-state instruments to better understand the space environment.
Success Criteria – Complete Payload

• Minimum Success Criteria:
  • Power and telemetry for all instruments throughout flight.

• Comprehensive Success Criteria:
  • Safe return of equipment to allow for reuse.
Full Payload ConOps

Altitude

$t = -180\text{s}$
- Power On

$t = 0\text{ min}$
- All systems on
  - Begin data collection

$Apogee$
- $t \approx 199.7\text{ sec}$
- Altitude: $\approx 153\text{ km}$
- WVSU Experiments Exposed to Space

$End of Malemute Burn$
- $t \approx 28.7\text{ sec}$
- Altitude: $17.2\text{ km}$

$t \approx 454.9\text{ sec}$
- Chute Deploys

$t \approx 861\text{ sec}$
- Internal Battery starts (TE-2)

$t \approx 876\text{ sec}$
- Splash Down
  - End of Telemetry
Payload Location

Final Positions

We are here

Aft

Exp5Sys2
Exp5Sys1
Exp4Sys2
Exp4Sys1
Exp3
Exp2
Exp1Sys2
Exp1Sys1

Forward
Pointing

• Please confirm the proposed rocket pointing

NOT FINALIZED YET. PLEASE LOOK FOR AN EMAIL WITH THE ACTUAL POINTING AT A LATER DATE
Full Payload ConOps

Altitude

$t = -180s$
- Power On

$t = 0\text{ min}$
- All systems on
- Begin data collection

$Apogee$
- $t \approx 199.7\text{ sec}$
- Altitude: $\approx 153\text{ km}$
- WVSU Experiments Exposed to Space

$End\ of\ Malemute\ Burn$
- $t \approx 28.7\text{ sec}$
- Altitude: $17.2\text{ km}$

$Chute\ Deploys$
- $t \approx 454.9\text{ sec}$

$Internal\ Battery\ starts\ (TE-2)$
- $t \approx 861\text{ sec}$

$Splash\ Down$
- $t \approx 876\text{ sec}$
- End of Telemetry
# Activation Sequence: CCofCO and WV

<table>
<thead>
<tr>
<th>Event</th>
<th>CCoC</th>
<th>Time On</th>
<th>Dwell Time</th>
<th>Description</th>
<th>Event</th>
<th>Time On</th>
<th>Dwell Time</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSE 1</td>
<td>WVC</td>
<td>T - 300 s</td>
<td>Flight</td>
<td>Power to Camera, Camera Pi and arm Pi</td>
<td>GSE 1</td>
<td>T - 300 s</td>
<td>Flight</td>
<td>Power to Camera, Camera Pi and arm Pi</td>
</tr>
<tr>
<td>GSE 2</td>
<td>WVC</td>
<td>T - 180 s</td>
<td>Flight</td>
<td>Power On</td>
<td>GSE 2</td>
<td>T - 180 s</td>
<td>Flight</td>
<td>Power On</td>
</tr>
<tr>
<td>TE-R</td>
<td>CCoC</td>
<td>T + 85 s</td>
<td>Flight</td>
<td>Arm Extesion</td>
<td>TE-R</td>
<td>T + 85 s</td>
<td>Flight</td>
<td>Arm Extesion</td>
</tr>
<tr>
<td>TE-1</td>
<td>CCoC</td>
<td>T + 270s</td>
<td>Flight</td>
<td>Power to camera arm motors and controller</td>
<td>TE-1</td>
<td>T + 270s</td>
<td>Flight</td>
<td>Power to camera arm motors and controller</td>
</tr>
</tbody>
</table>
# Pin Assignments: Power

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No Connection</td>
</tr>
<tr>
<td>2</td>
<td>NC</td>
</tr>
<tr>
<td>3</td>
<td>NC</td>
</tr>
<tr>
<td>4</td>
<td>NC</td>
</tr>
<tr>
<td>5</td>
<td>NC</td>
</tr>
<tr>
<td>6</td>
<td>NC</td>
</tr>
<tr>
<td>7</td>
<td>NC</td>
</tr>
<tr>
<td>8</td>
<td>NC</td>
</tr>
<tr>
<td>9</td>
<td>+28V (GSE 2)</td>
</tr>
<tr>
<td>10</td>
<td>TE-2</td>
</tr>
<tr>
<td>11</td>
<td>TE-3</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>
</tr>
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</table>
## Pin Assignments: Telemetry Interface

<table>
<thead>
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<th>Pin</th>
<th>Function</th>
<th>Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<tr>
<td>2</td>
<td>NC</td>
<td>21</td>
<td>PB8</td>
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<td>3</td>
<td>NC</td>
<td>22</td>
<td>PB9</td>
</tr>
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<td>4</td>
<td>NC</td>
<td>23</td>
<td>PB10</td>
</tr>
<tr>
<td>5</td>
<td>NC</td>
<td>24</td>
<td>PB11</td>
</tr>
<tr>
<td>6</td>
<td>NC</td>
<td>25</td>
<td>PB12</td>
</tr>
<tr>
<td>7</td>
<td>NC</td>
<td>26</td>
<td>PB13</td>
</tr>
<tr>
<td>8</td>
<td>NC</td>
<td>27</td>
<td>PB14</td>
</tr>
<tr>
<td>9</td>
<td>NC</td>
<td>28</td>
<td>PB15</td>
</tr>
<tr>
<td>10</td>
<td>NC</td>
<td>29</td>
<td>PB16 (LSB)</td>
</tr>
<tr>
<td>11</td>
<td>PB1 (MSB)</td>
<td>30</td>
<td>PRS</td>
</tr>
<tr>
<td>12</td>
<td>PB2</td>
<td>31</td>
<td>NC</td>
</tr>
<tr>
<td>13</td>
<td>PB3</td>
<td>32</td>
<td>NC</td>
</tr>
<tr>
<td>14</td>
<td>PB4</td>
<td>33</td>
<td>NC</td>
</tr>
<tr>
<td>15</td>
<td>PB5</td>
<td>34</td>
<td>NC</td>
</tr>
<tr>
<td>16</td>
<td>PB6</td>
<td>35</td>
<td>NC</td>
</tr>
<tr>
<td>17</td>
<td>NC</td>
<td>36</td>
<td>NC</td>
</tr>
<tr>
<td>18</td>
<td>GND</td>
<td>37</td>
<td>NC</td>
</tr>
<tr>
<td>19</td>
<td>NC</td>
<td></td>
<td></td>
</tr>
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</table>
# Updated Power Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Voltage (V)</th>
<th>Current (A)</th>
<th>Time On (min)</th>
<th>Amp-Hours</th>
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</thead>
<tbody>
<tr>
<td>WVSU</td>
<td>5</td>
<td>0.2</td>
<td>20</td>
<td>0.0179</td>
</tr>
<tr>
<td>WVWC</td>
<td>5</td>
<td>0.09090909</td>
<td>20</td>
<td>0.03</td>
</tr>
<tr>
<td>WVU</td>
<td>5</td>
<td>0.35</td>
<td>20</td>
<td>0.1155</td>
</tr>
<tr>
<td>BRCTC</td>
<td>5</td>
<td>0.9030303</td>
<td>20</td>
<td>0.298</td>
</tr>
<tr>
<td>Telemetry</td>
<td>3.3</td>
<td>0.75</td>
<td>20</td>
<td>0.2475</td>
</tr>
<tr>
<td>Power Distribution</td>
<td>5</td>
<td>0.25</td>
<td>20</td>
<td>0.0825</td>
</tr>
</tbody>
</table>

Total (A*hr): 0.140955357

Over/Under: Under by 0.35
Subsystem Design: Detailed Weight Budget

- Including Payload Deck, we are still a little heavy, will scale the enclosure to fit exact weight (as was done in previous years)

- Weight of payload deck is 3.425 lbs

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Total Weight (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WVWC</td>
<td>0.11</td>
</tr>
<tr>
<td>WVSU</td>
<td>0.19</td>
</tr>
<tr>
<td>BRCTC</td>
<td>0.93</td>
</tr>
<tr>
<td>WVU</td>
<td>0.25</td>
</tr>
<tr>
<td>Enclosure</td>
<td>11</td>
</tr>
<tr>
<td>Deck</td>
<td>3.425</td>
</tr>
<tr>
<td>Total</td>
<td>12.48</td>
</tr>
<tr>
<td>Over/Under</td>
<td>0.905</td>
</tr>
</tbody>
</table>
1.2.0 Design Overview
System Changes Since STR

• On slight alert over COVID-19
  • WVU is going to all online.
  • Shop is still active. Moving forward with enclosure construction
  • (WV) Integration still being planned for May
Mechanical Design Overview

- Combines best functioning designs from previous two flights
- Simple, top mounted enclosure
- Height set to 5” but can be shortened if needed.
- Separate enclosure shrunk and now for external batteries.
- New design (only partial modification) to be finalized this week.
System Overview: Science Design Overview

1. Processing Enclosure
2. Removed section
3. WVSU Geiger Tubes
4. WVSU Solar Array Assembly
5. WVU Experiment (small and not rendered here)
System Overview: Science Design Overview

- Rectangular connectors replaced with sealed circular potting connector.
- Better prevents water ingress.
- Not mission critical but is an overall design improvement.

Failure point in previous flight.
Battery and DC-DC converter located in enclosure on exposed section

Isolated DC/DC converter
- voltage regulation
- on/off control
  - on/off control via microcontroller and initiated by TE-2

3 cells in series
3.7V * 3 = 11.1V nominal
2.6Ah
18650 Lithium Ion
System Level: Power Distribution

GSE DC-DC converter

TE distribution

Individual experiment current limiting, short-circuit protection, power switching, monitoring
Power Distribution Event Logging

Microcontroller for power switching and event logging

Measurement analog conditioning
Power Distribution Board design coming along
Power Distribution System Testing

• Various value power resistors are connected to all outputs to test PDS under different loads and test logging capabilities.
  – Testing performed when supplied by GSE and internal battery
• Logging capabilities will be tested to ensure that experiment loads from 10 mA to 1 A and voltage can be measured and logged.
  – Provides capability to log power events during mission for post-flight diagnostics
• Full mission simulations performed to test GSE to battery transitioning
• Internal battery voltage logged throughout mission
Telemetry Interface System

Telemetry microcontroller (NetBurner NANO54415)

UART serial inputs from experiments (57,600 baud typically)

Redundant µSD card storage

Wallops parallel interface
Telemetry Interface Board (2018)
Telemetry Interface System Testing

• National Instruments DAQ system provides clocking of parallel interface
• Interfaces to computer via USB to LabVIEW program which logs parallel data
• Computer with 4 RS232 ports outputs known serial data to telemetry interface. Recorded data is compared to sent data
• Additional testing needed with actual experiments to work out problems with conflicting headers/footers or special characters.
1.3.0 Subsystem Testing Status

Name of Presenter
Subsystem Testing Status

• All have heritage from previous launch years
1.5.0 Plan for Full Mission Simulation Review (FMSR)

Name of Presenter
Mechanical Testing

- Will test all integrated system during integration in May.
1.6.0 Project Schedule

Name of Presenter
Schedule

• April: Build Enclosure and mount on Deck
• May: Integrate all Systems
• June: Fix any issues that arised during integration. Adjust weight of enclosure.
June Operations

• Currently Expect complete system availability in June
1.7.0 Project Management
## User Guide Compliance: Summary

<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>Yes</td>
</tr>
<tr>
<td>Weight 30.0+/- 1.0 (15.0 +/- 0.5) lbs?</td>
<td>Over, trivial plan to reduce (using an overestimate of enclosure weight)</td>
</tr>
<tr>
<td>Max Height &lt; 10.75” (5.13”)</td>
<td>5.00”</td>
</tr>
<tr>
<td>Bottom of deck has flush mount hardware?</td>
<td>YES, see picture on slide 54</td>
</tr>
<tr>
<td>Within Keep-Out Zone</td>
<td>Not any more</td>
</tr>
<tr>
<td>Using &lt; 10 A/D Lines</td>
<td>Yes</td>
</tr>
<tr>
<td>Using/Understand Parallel Line</td>
<td>Yes</td>
</tr>
<tr>
<td>Using/Understand Asynchronous Line</td>
<td>NO</td>
</tr>
<tr>
<td>Using X GSE Line(s)</td>
<td>YES, GSE 2</td>
</tr>
<tr>
<td>Using X Non-Redundant PWR Lines (TE-1, TE-2, TE-3)</td>
<td>YES, TE-3 and TE-3</td>
</tr>
<tr>
<td>Using X Redundant Power Lines (TE-R)</td>
<td>NO</td>
</tr>
<tr>
<td>Using &lt; 1 Ah (&lt; 0.5 Ah for half payload)</td>
<td>0.14 Ah</td>
</tr>
<tr>
<td>Using &lt;= 28 V</td>
<td>400-600 V (for Geiger counters ~microAmp)</td>
</tr>
<tr>
<td>Using RF (If yes, list frequency and TX Power)</td>
<td>NO</td>
</tr>
<tr>
<td>Using deployable?</td>
<td>NO</td>
</tr>
<tr>
<td>Whole team consists of US Persons</td>
<td>NO</td>
</tr>
<tr>
<td>Using ITAR and/or Export Controlled hardware</td>
<td>NO</td>
</tr>
</tbody>
</table>
## Latest Contact Matrix

### Space Flight Design Challenge

#### Fall 2018 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>WV Lead</td>
<td>Adam Kobelski</td>
<td>304-293-4713</td>
<td>406-624-9858</td>
<td>Yes</td>
<td><a href="mailto:adam.kobelski@mail.wvu.edu">adam.kobelski@mail.wvu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>WV Technical Lead</td>
<td>Gregory Lusk</td>
<td>304-293-0917</td>
<td>724-498-3385</td>
<td>Yes</td>
<td><a href="mailto:glusk@mail.wvu.edu">glusk@mail.wvu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>WV Mechanical Lead</td>
<td>Clayton Cobb</td>
<td>N/A</td>
<td>N/A</td>
<td>Yes</td>
<td><a href="mailto:crc0028@mix.wvu.edu">crc0028@mix.wvu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>BRCTC Advisor</td>
<td>Gervase Willis</td>
<td>(304)-596-4091</td>
<td>(304)-596-4091</td>
<td>Yes</td>
<td><a href="mailto:gwillis@blueridgectc.edu">gwillis@blueridgectc.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>BRCTC Advisor</td>
<td>David Teets</td>
<td>(540)-325-4651</td>
<td>(540)-325-4651</td>
<td>Yes</td>
<td><a href="mailto:dteets@blueridgectc.edu">dteets@blueridgectc.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>BRCTC Assistant</td>
<td>Adam Bridendolph</td>
<td>(304)-260-4380</td>
<td>(304)-260-4380</td>
<td>Yes</td>
<td><a href="mailto:abriend@blueridgectc.edu">abriend@blueridgectc.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>BRCTC Team Lead</td>
<td>Ronald Willis</td>
<td>(717)-357-6172</td>
<td>(717)-357-6172</td>
<td>Yes</td>
<td><a href="mailto:rwilli12@my.blueridgectc.edu">rwilli12@my.blueridgectc.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>West Virginia State University</td>
<td>Team Leader Taylor Jones-Martin</td>
<td>N/A</td>
<td>304-993-6459</td>
<td>Yes</td>
<td><a href="mailto:jonesmartin@wvstateu.edu">jonesmartin@wvstateu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>West Virginia State University</td>
<td>Team Member Ashlea Simmons</td>
<td>N/A</td>
<td>304-590-6323</td>
<td>Yes</td>
<td><a href="mailto:asimmer@wvstateu.edu">asimmer@wvstateu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>West Virginia State University</td>
<td>Team Member Chris Bia</td>
<td>N/A</td>
<td>304-380-3672</td>
<td>Yes</td>
<td><a href="mailto:cbiaxk@wvstateu.edu">cbiaxk@wvstateu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>West Virginia State University</td>
<td>Faculty Advisor Marek Krasnansky</td>
<td>304-768-5257</td>
<td>N/A</td>
<td>No</td>
<td><a href="mailto:mkrasnansky@wvstateu.edu">mkrasnansky@wvstateu.edu</a></td>
<td>Slovakia</td>
<td>Yes</td>
</tr>
<tr>
<td>West Virginia State University</td>
<td>Team Member Romould Peera</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td><a href="mailto:wshali5@wvstateu.edu">wshali5@wvstateu.edu</a></td>
<td>Sri Lanka</td>
<td>Yes</td>
</tr>
<tr>
<td>West Virginia State University</td>
<td>Team Member Jon Musselwhite</td>
<td>N/A</td>
<td>304-719-7914</td>
<td>Yes</td>
<td><a href="mailto:jonmusselwhite@wvstateu.edu">jonmusselwhite@wvstateu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Rocket Dynamics/West Virginia Wesleyan College:</td>
<td>Faculty Advisor Tracey DeLaney</td>
<td>304-473-8330</td>
<td>857-598-1331</td>
<td>Yes</td>
<td><a href="mailto:email@address.com">email@address.com</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Rocket Dynamics/West Virginia Wesleyan College:</td>
<td>Team Lead Justin Knotts</td>
<td>304-685-4184</td>
<td>Yes</td>
<td><a href="mailto:knotts.j.2018@wvwc.edu">knotts.j.2018@wvwc.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Rocket Dynamics/West Virginia Wesleyan College:</td>
<td>Electrical Lead Justin Bibey</td>
<td>681-288-8780</td>
<td>Yes</td>
<td><a href="mailto:bibey.j.2018@wvwc.edu">bibey.j.2018@wvwc.edu</a></td>
<td>U.S.</td>
<td>No</td>
<td></td>
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<tr>
<td>Rocket Dynamics/West Virginia Wesleyan College:</td>
<td>Mechanical Lead Rian Bigsby</td>
<td>240-454-1756</td>
<td>Yes</td>
<td><a href="mailto:bigsby.r.2018@wvwc.edu">bigsby.r.2018@wvwc.edu</a></td>
<td>U.S.</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Rocket Dynamics/West Virginia Wesleyan College:</td>
<td>Software Lead Megan Long</td>
<td>304-692-8734</td>
<td>Yes</td>
<td><a href="mailto:long.m.2018@wvwc.edu">long.m.2018@wvwc.edu</a></td>
<td>U.S.</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Rocket Dynamics/West Virginia Wesleyan College:</td>
<td>Underwear Lead Andrew Irvin</td>
<td>240-692-1376</td>
<td>Yes</td>
<td><a href="mailto:irvin.am.2018@wvwc.edu">irvin.am.2018@wvwc.edu</a></td>
<td>U.S.</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Rocket Dynamics/West Virginia Wesleyan College:</td>
<td>Team member Joel Carty</td>
<td>304-588-3716</td>
<td>Yes</td>
<td><a href="mailto:carly.j.2016@wvwc.edu">carly.j.2016@wvwc.edu</a></td>
<td>U.S.</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Rocket Dynamics/West Virginia Wesleyan College:</td>
<td>Team member Abigail O'Shields</td>
<td>302-296-7111</td>
<td>Yes</td>
<td><a href="mailto:oshields.am.2019@wvwc.edu">oshields.am.2019@wvwc.edu</a></td>
<td>U.S.</td>
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<tr>
<td>Rocket Dynamics/West Virginia Wesleyan College:</td>
<td>Team member Richard Calo</td>
<td>304-240-5778</td>
<td>Yes</td>
<td><a href="mailto:calo.ra.2017@wvwc.edu">calo.ra.2017@wvwc.edu</a></td>
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<tr>
<td>Rocket Dynamics/West Virginia Wesleyan College:</td>
<td>Team member Virginia Martin</td>
<td>240-727-9456</td>
<td>Yes</td>
<td><a href="mailto:martin.v.2019@wvwc.edu">martin.v.2019@wvwc.edu</a></td>
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<td>Rocket Dynamics/West Virginia Wesleyan College:</td>
<td>Team member Kayleigh Anderson</td>
<td>304-784-0583</td>
<td>Yes</td>
<td><a href="mailto:sensor.ln.2018@wvwc.edu">sensor.ln.2018@wvwc.edu</a></td>
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<tr>
<td>West Virginia University:</td>
<td>WV Lead Adam Kobelski</td>
<td>304-293-4713</td>
<td>406-624-9858</td>
<td>Yes</td>
<td><a href="mailto:adam.kobelski@mail.wvu.edu">adam.kobelski@mail.wvu.edu</a></td>
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<tr>
<td>West Virginia University:</td>
<td>Team Leader Clayton Cobb</td>
<td>N/A</td>
<td>818-889-6113</td>
<td>Yes</td>
<td><a href="mailto:crc0026@mix.wvu.edu">crc0026@mix.wvu.edu</a></td>
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<tr>
<td>West Virginia University:</td>
<td>Team Member Brian Frongello</td>
<td>N/A</td>
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<td><a href="mailto:bfrongel0@mix.wvu.edu">bfrongel0@mix.wvu.edu</a></td>
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<td>West Virginia University:</td>
<td>Team Member Daniel Ligon</td>
<td>N/A</td>
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<td><a href="mailto:dligon02@mix.wvu.edu">dligon02@mix.wvu.edu</a></td>
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<td>Team Member Jerin Wishman</td>
<td>N/A</td>
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<td>Team Member Matteo Cerasoli</td>
<td>N/A</td>
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<td><a href="mailto:mdcceras@mix.wvu.edu">mdcceras@mix.wvu.edu</a></td>
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<td>Team Member Kayleigh Anderson</td>
<td>N/A</td>
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<td><a href="mailto:kaal0333@mix.wvu.edu">kaal0333@mix.wvu.edu</a></td>
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<tr>
<td>West Virginia University:</td>
<td>Team Member Jackson Crousse</td>
<td>N/A</td>
<td>Yes</td>
<td><a href="mailto:jac0104@mix.wvu.edu">jac0104@mix.wvu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>
1.8.0 Conclusions
Worries and Concerns

• COVID-19 making integration/launch “difficult”
  – Will continue to make cautious progress, develop plan to fly at a delayed date.
2.0.0 WVSU Overview

Taylor Jones-Martin
2.1.0 Mission Overview

*Name of Presenter*
Mission Overview: Mission Statement

• Provide hands-on experience with designing and building space related experiments.
• Prepare for potential future CubeSat missions by comparing component designs.
• Improve designs from previous years.
Mission Overview: Mission Objectives

• Geiger Counters
  – Will be made as small as possible while still being efficient.
  – Different tubes will be compared to see which is most efficient.
  – Minimum success – Radiation detection.

• Si PIN Diode Particle Detectors and Photosensors
  – Detection of radiation with particle detectors, determine orientation of rocket relative to the sun, and determine direction of radiation with respect to the sun.
  – Minimum success – Obtain solar cell, photosensor, and radiation data.

• Flight Dynamics (acceleration and rotation rates), Magnetic Fields, and Temperature/Pressure
  – Minimum success – Acquire data describing flight dynamics, magnetic fields, and temperature.
Mission Overview: Theory and Concepts

• The SBM20, SBM21, LND 713 Geiger-Muller Tubes were used in the 2019.
  – In 2016, detected radiation was 250 counts/sec.
  – In 2017 and 2018, detected radiation was around 10 counts/sec.
  – In 2019, detected radiation was up to 6 count/sec.

• How the tubes work:
  – Ionizing radiation enters the tube from one direction (primarily).
  – When high voltage is applied to the tube, the alpha, beta, and gamma particles’ ionization effect is amplified.
  – Every time a particle is detected, the circuit registers a single pulse.
  – There is a dead-time after each count is recorded; during this time, ionizing radiation particles that hit the tube cannot be counted.
Mission Overview: Theory and Concepts

Si PIN Diode Particle Detectors

- Si PIN diode detectors will be positioned on each axis.
- Particles that strike the detector with enough energy will cause the ionization of the intermediate layer.
- This ionization results in an electric current that we can measure.
Mission Overview: Theory and Concepts

• By measuring light intensity and radiation (counts/sec), we can determine the direction of the sun and the direction of the radiation relative to the sun.

• VEML6070 UV index sensor and Pocket Geiger Type 5 particle detectors have been tested.
  – The VEML6070 UV index sensors and Pocket Geiger Type 5 particle detectors require little to no electrical components and provide easily interpreted data.
Mission Overview: Theory and Concepts

• Flight Data
  – The previous year’s IMU worked very well detecting with high sensitivity: magnetic field, rotation, and acceleration. The acceleration of the rocket was greater than the scale of the IMU. Therefore, a dedicated accelerometer that can detect high values will be used together with the high precision IMU.

• Temperature/Pressure
  – Will be used to measure the temperature and pressure inside and outside of the enclosure.
Mission Overview: Success Criteria

**Minimum Success Criteria:**
- Geiger Counters: Radiation detection.
- Si Particle Detectors: Obtain radiation data.
- Photosensors: Measure amount of light.
- Flight Dynamics, Temperature, Pressure: Acquire data describing flight dynamics, magnetic fields, and temperature.

**Comprehensive Success Criteria:**
- Si Particle Detectors: Determine direction of radiation.
- Photosensors: Determine direction of the sun.
- Flight Dynamics, Temperature, Pressure: Acquire data describing flight dynamics, magnetic fields, and temperature.
## Top Level Requirements:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification Method</th>
<th>Description</th>
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<tbody>
<tr>
<td>Data acquisition</td>
<td><strong>Test</strong></td>
<td>Testing simulated mission conditions while a computer monitors telemetry output</td>
</tr>
<tr>
<td>All components shall be securely mounted to survive stresses of launch</td>
<td><strong>Test</strong></td>
<td>System will be exposed to vibrations</td>
</tr>
<tr>
<td>Each subsystem will be independent and a failure in one will not affect the others</td>
<td><strong>Analysis and Test</strong></td>
<td>Simulated failures in systems will verify this requirement</td>
</tr>
</tbody>
</table>
Mission Overview: Expected Results

• Geiger Counters
  – Radiation is expected to range anywhere from 6 to 300 counts/sec. It is expected that the count will be closer to the lower end.

• Si PIN Particle Detectors and Photosensors
  – Expected radiation levels are anywhere between 6-300 counts/sec, based on previous years’ data.
  – Each solar cell should measure a unique level of solar intensity, depending on the axis of the cell and position of the Sun.
  – Each photodiode should be sensitive enough to determine solar orientation.
  – All solar sensors (UV Index, Lux, Polycrystalline cells, diodes) expected to record constant data when payload is exposed.

• Flight Data
  – Values of magnetic field, acceleration, rotational velocity, temperature and pressure will be similar to previous years.
2.2.0 Design Overview
System Changes Since CDR

• No changes since CDR
• All systems are same as listed in CDR
• No change in objectives or requirements
## Subsystem Design: Detailed Weight Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Total Weight (g)</th>
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<tbody>
<tr>
<td>Command and Data Handling</td>
<td>6.370</td>
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<tr>
<td>IMU</td>
<td>2.100</td>
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<tr>
<td>Accelerometer</td>
<td>1.270</td>
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<tr>
<td>Temp/Press</td>
<td>0.028</td>
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<tr>
<td>Geiger Circuits</td>
<td>76.000</td>
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<tr>
<td>SiPIN Detectors</td>
<td>2.100</td>
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<tr>
<td>Photovoltaic Cells</td>
<td>0.028</td>
</tr>
<tr>
<td>UV Sensors</td>
<td>0.028</td>
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<tr>
<td>LUX</td>
<td>0.028</td>
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<tr>
<td><strong>Total (g)</strong></td>
<td><strong>87.952</strong></td>
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<tr>
<td><strong>Over/Under (g)</strong></td>
<td><strong>6712.048</strong></td>
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</table>
System Overview: Electrical Design
Flight Dynamics and Command/Data Handling

- **BMP280**
  - (19.2 x 17.9 x 2.9) mm
  - 1.3 g
- **IMU**
  - (28.3 x 20.5 x 3.0) mm
  - 2.1 g
- **OpenLog**
  - (10.82 x 19.78 x 3.90) mm
  - 1.67 g
- **ADXL 377**
  - (19 x 19 x 3.14) mm
  - 1.27 g
- **Teensy**
  - (35.64 x 17.86 x 4.46) mm
  - 2.90 g
Subsystem: Command and Data Handling

• All experiments are controlled by Teensy 3.2.
  – IMU, Temperature/Pressure, and UV detectors will be controlled using I2C.
    – An I2C expander will be used to manage overlapping I2C addresses
    – 30.6mm x 17.6mm x 2.7mm
    – 1.8g
    – Geiger counters and Si PIN detectors will use digital input.
    – All others will use analog input

• Data will be recorded using serial interface through SparkFun OpenLog to a microSD card.

• This design is final
Command and Data Handling

• Microcontroller and I2C multiplexer are functional
• Working code has been developed, but is in the process of being improved
Flight Dynamics

• Each part of the flight dynamics has been tested and they all turn on and work as expected
• Need to further test the ADXL377 in order to test for accuracy
Subsystem Design: Flight Dynamics

- Will use
  - NXP Precision 9DoF Breakout IMU from Adafruit.
  - ADXL377 High-G 3-Axis Accelerometer from Adafruit.
  - BMP280 Pressure and Temperature Sensor from Adafruit.
- Controlled by Teensy 3.2
- This design is final.
Subsystem: Particle Detectors (SiPIN)

• Pocket Geiger Radiation Sensor: Type 5
  – (5.5 x 2.5 x 0.38) cm
Subsystem: Photosensors

• Adafruit VEML6070 UV Index Sensor
  - (1.4 x 1.3 x 0.30) cm
  - 0.5 g
Subsystem: Geiger Counters

Geiger Counter Schematics
Geiger Counters

SBM 20: Specifications (Right), Pictured Below.

SBM 10: Specifications (Left), Pictured Below.

### GENERAL SPECIFICATIONS

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
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<tr>
<td>Gas Filling</td>
<td>Ne + Halogen</td>
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<td>Cathode Material</td>
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<td>35 mm</td>
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<td>Effective Diameter</td>
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<td>Connector</td>
<td>Pin</td>
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<td>Operating Temperature Range</td>
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### WALL SPECIFICATIONS

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### ELECTRICAL SPECIFICATIONS

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<td>Voltage of start of counting</td>
<td>260 – 320 V</td>
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<tr>
<td>Plateau length</td>
<td>at least 100 V</td>
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<td>Maximum Plateau Slope</td>
<td>15% / 100 V</td>
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<td>Minimum Dead Time at U=400V</td>
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<tr>
<td>Working range</td>
<td>0.04 – 400 μR/s</td>
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<td>Working range</td>
<td>0.14 – 1440 mR/hr</td>
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<td>Pulses amplitude</td>
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<td>Maximum counting frequency</td>
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<td>Gamma Sensitivity Cs^{60}</td>
<td>3.3 cps/mR/hr</td>
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<td>Gamma Sensitivity Cs^{137} at P=10 mkRoentgen</td>
<td>9.6...10.8 cps</td>
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<td>Inherent counter background</td>
<td>0.13 cps</td>
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<td>Tube Capacitance</td>
<td>2 pf</td>
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<td>Dead time at U=400V</td>
<td>64 μs</td>
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<tr>
<td>Life</td>
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<td>Weight</td>
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<td>Insulation resistance</td>
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### Specifications

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<td>Tube Capacitance (pf)</td>
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<td>Life (pulses)</td>
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<td>Weight (grams)</td>
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Geiger Counters

LND 712: Specifications (Left), Pictured below.

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<td><strong>Gas Filling</strong></td>
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<td><strong>Cathode Material (Internal/External)</strong></td>
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<td><strong>Effective Diameter (Inch/ MM)</strong></td>
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<td><strong>Connector</strong></td>
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<td><strong>Operating Temperature Range °C</strong></td>
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<td><strong>Recommended Anode Resistor (Meg Ohm)</strong></td>
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<tr>
<td><strong>Operating Voltage Range (Volts)</strong></td>
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<tr>
<td><strong>Maximum Plateau Slope (V/100 Volts)</strong></td>
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<td><strong>Minimum Dead Time (Micro Sec)</strong></td>
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<td><strong>Gamma Sensitivity CPM (CPM/µR/HR)</strong></td>
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<td><strong>Tube Capacitance (PF)</strong></td>
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<td><strong>Maximum Background Shielded 50 Mm PE + 2MM AL (CPM)</strong></td>
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<td><strong>Minimum Anode Resistor (Meg Ohm)</strong></td>
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LND 713: Specifications (Right), Pictured below.

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<td><strong>Effective Length (Inch/ MM)</strong></td>
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<th>Window Specifications</th>
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<td><strong>Material</strong></td>
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<tr>
<td><strong>Areal Density (mg/cm²)</strong></td>
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<tr>
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<tbody>
<tr>
<td><strong>Recommended Operating Voltage (Volts)</strong></td>
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<tr>
<td><strong>Recommended Anode Resistor (Meg Ohm)</strong></td>
</tr>
<tr>
<td><strong>Operating Voltage Range (Volts)</strong></td>
</tr>
<tr>
<td><strong>Maximum Plateau Slope (V/100 Volts)</strong></td>
</tr>
<tr>
<td><strong>Minimum Dead Time (Micro Sec)</strong></td>
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<tr>
<td><strong>Gamma Sensitivity CPM (CPM/µR/HR)</strong></td>
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<tr>
<td><strong>Tube Capacitance (PF)</strong></td>
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<tr>
<td><strong>Weight (Grams)</strong></td>
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<tr>
<td><strong>Maximum Background Shielded 50 Mm PE + 2MM AL (CPM)</strong></td>
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<tr>
<td><strong>Maximum Starting Voltage (Volts)</strong></td>
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</table>
Subsystem: Geiger Counters

Mechanical and Electrical Interfaces:
- Geiger Tubes will use 3.3 Volts.
- Signal will be read by a digital pin from the Teensy 3.2.
  - Each Geiger counter will need a separate Pin.

Hardware Required:
- SBM 10
- SBM 20
- LND 712
  - Total height: 15.4 mm
  - Est. mass: 11.19 g
- LND 713
  - Total height: 18.7 mm
  - Est. mass: 18.69 g

Other:
- The drawings which are shown on the right represent a general layout of each Geiger Counter. These numbers are subject to minor change.
Materials List

- LND 712
- LND 713
- SBM 10
- SBM 20
- Resistors, capacitors, diodes, transistors, inductors, connectors.
## WVSU Power Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Voltage (V)</th>
<th>Current (A)</th>
<th>Time On (min)</th>
<th>Amp-Hours</th>
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</thead>
<tbody>
<tr>
<td>Geiger Circuits</td>
<td>5</td>
<td>0.08</td>
<td>20</td>
<td>0.027</td>
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<td>IMU</td>
<td>5</td>
<td>0.003</td>
<td>20</td>
<td>0.001</td>
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<td>SiPIN Detectors</td>
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<td>20</td>
<td>0.010</td>
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<tr>
<td>Photodiodes</td>
<td>5 0.000000003</td>
<td>0.000000003</td>
<td>20</td>
<td>0.000</td>
</tr>
<tr>
<td>Temp/Press Accelerometer</td>
<td>5</td>
<td>0.025</td>
<td>20</td>
<td>0.008</td>
</tr>
<tr>
<td>LUX</td>
<td>5</td>
<td>0.0012</td>
<td>20</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Total (A*hr): 0.063

Over/Under: 0.437
Hazardous Electrical Items

• Geiger counters operate at (400 – 600) V
Software Elements

- Power on GSE-1
- Read T/P 1
- Read Geiger 1
- Read Accel.
- Read IMU
- Read Geiger 2
- Read Geiger 3
- Read T/P 2
- Read Geiger 4
- Read Geiger 5

Software is being designed for all components

- Read SiPIN 1
- Read SiPIN 2
- Read SiPIN 3
- Read UV 1
- Read UV 2
- Read UV 3
- Read PV 1
- Read PV 2
- Read PV 3
Software Design

• Working code has been designed
• Faster code is being developed in order to reach an ideal 50 reads
De-Scopes and Off-Ramps

• Every experiment is functioning except the photovoltaic cells that haven’t arrived
Special Requests

• Geiger counters have high voltage (400 – 600) V
2.3.0 Hardware Procurement Status

Name of Presenter
Mechanical Elements

• Outside mount needs to be manufactured
Electrical Elements

• Need to design and order PCBs
• Will have to purchase additional circuit components for Geiger counter PCBs
• All major components have arrived
Software Elements

- Each experiment has working code
- More efficient code is being developed
Mechanical Elements

• Outside mount has been manufactured
Electrical Elements

• Need to design and order PCBs
• Will have to purchase additional circuit components for Geiger counter PCBs
• All major components have arrived
Software Elements

- Each experiment has working code
- More efficient code is being developed
Hazardous Electrical Items

• Geiger counters have high voltage
2.3.0 Subsystem Testing Status

Name of Presenter
Testing Results

- VEML6070 UV index sensor and SiPIN particle detectors have been tested.
  - Require little to no electrical components and provide easily interpreted data.
- Geiger Counters
  - Successfully breadboarded and tested.
- Flight dynamics
  - Successfully tested
  - I2C multiplexer is functional
Testing Results

- Flight dynamics functionality test
Testing Results

- SiPIN detectors connected to teensy
  - Received signal from $\beta$ and $\gamma$ sources
Testing Results

Testing results of SBM 20. Oscilloscope shows signal output from Geiger Counter.
Testing Results

Testing results of SBM 10. Oscilloscope shows signal output from Geiger Counter.
Testing Results

Testing results of LND 712. Oscilloscope shows signal output from Geiger Counter.
Testing Results

Testing results of LND 713. Oscilloscope shows signal output from Geiger Counter.
2.4.0 Integrated Subsystem Testing Status
Each SiPIN, VEML 6070, and BMP 280 were tested and functional. The SBM10 circuit was used as a model for the other Geiger counters and is functional. The IMU and ADXL377 are in working order. Last step is to test the OpenLog and another serial line to verify the ability to record data and send it out.
2.5.0 Plan for Full Mission Simulation Review (FMSR)

Name of Presenter
Testing

• Each component to be attached to the external mount will be attached
• Once PCBs are obtained, each component will be soldered and the payload will be tested as it is intended to be used
• The software will be tested as a confirmation of the electrical testing
Plan for FMSR

• Geiger Counter PCB designs are complete
• Main PCB design is almost complete
• Focus is to order PCBs asap
2.6.0 Project Schedule

Name of Presenter
Schedule

• April
  • PCBs arrive, components are soldered, and the system tested
• May
  • Meet up with WVU
• June
  • Make any last minute changes
June Operations

- Full payload should be available for June testing
## User Guide Compliance: Summary

<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></td>
</tr>
<tr>
<td>Weight 30.0+/- 1.0 (15.0 +/- 0.5) lbs?</td>
<td></td>
</tr>
<tr>
<td>Max Height &lt; 10.75” (5.13”)</td>
<td></td>
</tr>
<tr>
<td>Bottom of deck has flush mount hardware?</td>
<td></td>
</tr>
<tr>
<td>Within Keep-Out Zone</td>
<td></td>
</tr>
<tr>
<td>Using &lt; 10 A/D Lines</td>
<td></td>
</tr>
<tr>
<td>Using/Understand Parallel Line</td>
<td></td>
</tr>
<tr>
<td>Using/Understand Asynchronous Line</td>
<td></td>
</tr>
<tr>
<td>Using X GSE Line(s)</td>
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</tr>
<tr>
<td>Using X Non-Redundant PWR Lines (TE-1, TE-2, TE-3)</td>
<td></td>
</tr>
<tr>
<td>Using X Redundant Power Lines (TE-R)</td>
<td></td>
</tr>
<tr>
<td>Using &lt; 1 Ah</td>
<td></td>
</tr>
<tr>
<td>Using &lt;= 28 V</td>
<td>Geiger Counters will use 400 V to 600 V</td>
</tr>
<tr>
<td>Using RF (If yes, list frequency and TX Power)</td>
<td></td>
</tr>
<tr>
<td>Using deployable?</td>
<td></td>
</tr>
<tr>
<td>Whole team consists of US Persons</td>
<td></td>
</tr>
<tr>
<td>Using ITAR and/or Export Controlled hardware</td>
<td></td>
</tr>
</tbody>
</table>
2.7.0 Project Management

Name of Presenter
PMP: Management

- Taylor Jones-Martin – Team Lead
- Ashlea Simmers – Geiger Counters
- Christopher Bias – Solar Orientation
- Jon Musselwhite – Programming
- Dr. Marek Krasnansky – Faculty Advisor
## Latest Contact Matrix

### Team Name/School Here: West Virginia State University

#### Fall 2018 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>Team Leader</td>
<td>Taylor Jones-Martin</td>
<td>N/A</td>
<td>304-993-6459</td>
<td>Yes</td>
<td><a href="mailto:tjonesmartin@wvstateu.edu">tjonesmartin@wvstateu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Team Member</td>
<td>Ashlea Simmers</td>
<td>N/A</td>
<td>304-590-5323</td>
<td>Yes</td>
<td><a href="mailto:asimmers@wvstateu.edu">asimmers@wvstateu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Team Member</td>
<td>Chris Bias</td>
<td>N/A</td>
<td>304-380-3672</td>
<td>Yes</td>
<td><a href="mailto:cbias4@wvstateu.edu">cbias4@wvstateu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
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<tr>
<td>Faculty Advisor</td>
<td>Marek Krasnansky</td>
<td>304-7663257</td>
<td>N/A</td>
<td>No</td>
<td><a href="mailto:mkrasnansky@wvstateu.edu">mkrasnansky@wvstateu.edu</a></td>
<td>Slovakia</td>
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</tr>
<tr>
<td>Team Member</td>
<td>Jon Musselwhite</td>
<td>N/A</td>
<td>304-719-7914</td>
<td>Yes</td>
<td><a href="mailto:jonmusselwhite@wvstateu.edu">jonmusselwhite@wvstateu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
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</table>
3.0.0 WVWC Rocket Dynamics

Integrated Subsystem Testing Review (ISTR)
West Virginia Wesleyan College

Team Lead: Justin Knotts
Electrical Lead: Justin Bibey
Software Lead: Meggan Long
Mechanical Lead: Rian Bigsby

03/15/2020
Presentation Outline

• Section 1: Mission Concept and Interfaces
• Section 2: Design Overview
• Section 3: Subsystem Testing Status
• Section 4: Integrated Subsystem Testing Status
• Section 5: Plan for FMSR
• Section 6: Project Schedule
• Section 7: Project Management
• Section 8: Conclusion
3.1.0 Mission Concept and Interfaces

Justin Knotts

Dr. Tracey DeLaney
Mission Overview

• **Mission Statement** - We will use one Inertial Measurement Unit (IMU) and one high-G accelerometer to study rocket motion during a multi-stage parabolic space flight.

• **We will learn several things about rocket dynamics:**
  – forces at liftoff and at stage separation.
  – how the rocket spin changes throughout the flight
  – the vibrational motions of the rocket during the flight

• **Who benefits?**
  – Our team of undergraduate students will have firsthand access to real rocket flight data, which is a tremendous opportunity at the undergraduate level.

• **Why we should fly?**
  – Our goal is to study Rocket Dynamics, this is the only mission that will suffice.
Success Criteria

• Minimum Success Criteria:
  • Payload receives power, one sensor takes data, data stored somewhere (locally or telemetry)

• Comprehensive Success Criteria:
  • Receive all data from IMU and accelerometer and all data stored locally and via WVU and RockSat telemetry
Concept of Operations

• Receive power before liftoff and system initializes
• At launch and throughout flight
  – Data from IMU – 3-axis gyroscope, 3-axis accelerometer, 3-axis magnetometer, pressure, temperature
  – Data from 3-axis High-G accelerometer
  – Math on Arduino
  – Save data on local SD card
  – Send data over telemetry line as well
• When payload shifts to onboard battery, continue taking data to splashdown
WVWC ConOps

Altitude

- All systems on
  - Begin data collection

- Apogee
  - $t \approx 3.1$ min
  - Altitude: $\approx 150$ km

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

- Chute Deploys
  - $t \approx 7.5$ min

- Splash Down
  - $t \approx 15$ min
Activation Sequence: WVWC

- WVWC Timer Events

<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>flight</td>
<td>WVWC experiment powers on, initialized in time to measure forces at launch</td>
</tr>
</tbody>
</table>
## Updated 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>Amp-Hours</th>
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<tbody>
<tr>
<td>WVWC-Arduino</td>
<td>5</td>
<td>0.015</td>
<td>18</td>
<td>0.075</td>
<td>0.0045</td>
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<tr>
<td>WVWC-OpenLog</td>
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<td>0.0018</td>
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<tr>
<td>WVWC-IMU</td>
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<td>0.007</td>
<td>18</td>
<td>0.035</td>
<td>0.0021</td>
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<tr>
<td>WVWC-Accelerometer</td>
<td>5</td>
<td>0.006</td>
<td>18</td>
<td>0.030</td>
<td>0.0018</td>
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<tr>
<td>WVWC-LEDs</td>
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<td>0.070</td>
<td>18</td>
<td>0.350</td>
<td>0.0210</td>
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<td>Total:</td>
<td></td>
<td></td>
<td></td>
<td>0.520</td>
<td>0.0312</td>
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*Over/Under*
## Detailed Weight Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Total Weight (lbf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WVWC</td>
<td>.11</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
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<tr>
<td></td>
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<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0.11</td>
</tr>
</tbody>
</table>

*Over/Under*
2.0 Design Overview

Justin Knotts
Dr. Tracey DeLaney
System Changes Since STR

- To my knowledge nothing assigned to WVWC at STR

- No changes made to WVWC payload since STR
Design Overview

- Student J. Knotts downloaded Fusion 360
  - Learned how to import stp file from WVU for PCB
  - Learned how to import and manipulate stp file for Arduino
  - Intends to add other components to drawing
Functional Block Diagram

- **BNO055 IMU**
  - Serial I2C
  - Analog
- **Arduino ProMicro**
  - Data line - UART
- **ADXL377 Accelerometer**
  - Serial TX
- **openlog**
  - +5V
  - GND

From WVU To WVU
Hazardous Mechanical Items

• None
Hazardous Electrical Items

• None
Special Requests

• None
Update on Partnerships

• We are collaborating with
  – WVU and other West Virginia Schools
  – NASA WV Space Grant Consortium
  – NASA IV & V facility in Fairmont WV
3.3.0 Subsystem Testing Status
Subsystem Testing Status

Subsystem WVWC

Arduino, IMU, accelerometer, and OpenLog all tested and working together

Managed to change baud rate of OpenLog to 57600 and to output raw data from IMU

Need to order printed PCBs and calibrate IMU and accelerometer
3.6.0 Project Schedule

Justin Knotts
Dr. Tracey DeLaney
WVWC – Schedule

• March, 2020 – Calibrate IMU and accelerometer
• March, 2020 – Finalize and order printed circuit boards. Finalize C-code
• April, 2020 – Assemble parts on printed circuit board, perform shake test
• May, 2020 – Final Integration with West Virginia Team.
June Operations

- **WVWC**: everything should be present
3.7.0 Project Management

*Justin Knotts*

*Dr. Tracey DeLaney*
Payload Special Operations/Inhibits

- None
Project Management Update

• Team Picture
• No changes to Org chart
• WVU has master contact matrix
• WVU in charge of overall schedule
• WVWC monetary budget
• Worries and Concerns: Covid-19
  – Since we only have calibration, ordering PCBs, and soldering to PCBs, we can complete this payload
  – Since colleges and universities are closed, and we need to practice social distancing, this might affect integration
Management – WVWC Organizational Chart

Team Lead
Justin Knotts

Faculty Mentor
Dr. Tracey DeLaney

Software Lead
Meggan Long

Electrical Lead
Justin Bibey

Mechanical Lead
Rian Bigsby
WVWC – Schedule

• March, 2020 – Calibrate IMU and accelerometer
• March, 2020 – Finalize and order printed circuit boards. Finalize C-code
• April, 2020 – Assemble parts on printed circuit board, perform shake test
• May, 2020 – Final Integration with West Virginia Team.
Management - Budget

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCB</td>
<td>$200</td>
</tr>
<tr>
<td>Connectors and Miscellaneous Parts</td>
<td>60</td>
</tr>
<tr>
<td>2 Arduino Pro Micro</td>
<td>40</td>
</tr>
<tr>
<td>2 Openlog</td>
<td>30</td>
</tr>
<tr>
<td>2 IMU's</td>
<td>70</td>
</tr>
<tr>
<td>2 accelerometers</td>
<td>50</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$450</strong></td>
</tr>
</tbody>
</table>

This budget includes primary and backup units.
3.8.0 Conclusions

Justin Knotts
Dr. Tracey DeLaney
Conclusion

- Covid-19?
4.0.0 BRCTC SPACE
Integrated Subsystems Test Review (ISTR)

Blue Ridge Community & Technical College
Ronald Willis, Walter Willis, Christopher Sibole,
Alberto Torres, Nakyea Murphy, Corey Hummer,
Jennifer Schoppert, Uriah Horst
4.1.0 Mission Concept and Interfaces

Ronald Willis
Mission Overview

- The goal of BRCTC Vibe is to successfully record an accurate vibration profile (Power Spectral Density or Frequency Analysis) of the canister in the rocket to provide vital hertz data to future Rocksat teams. We expect to record accurate, high resolution hertz data which will be presented on paper and in an animated VR environment.
- Our experiment needs to have the accelerometers/gyro fastened in place, constant power, and a telemetry line.
- We expect to see a combination of vibration frequencies that change throughout the flight. The strongest vibrations will be seen during launch and atmospheric entry.
- Any team with a sensitive experiment can benefit from having data on the physical environment in which their experiment will be fastened.
Success Criteria

MINIMUM SUCCESS CRITERIA:
- The least amount of data we can collect that will still constitute a success is the redundant data from the gyroscope, or a single COTS Accelerometer.

COMPREHENSIVE SUCCESS CRITERIA:
- The ideal amount of data to have full or comprehensive mission success is usable data from all three COTS on each axis, with the additional gyroscope data.
Example ConOps

Altitude

- All systems on
- Begin data collection

$t \approx 1.3$ min
Altitude: 75 km
*Data Collection*

$t \approx 1.7$ min
Altitude: 95 km

Apogee
$t \approx 3.1$ min
Altitude: $\approx$150 km
*Data Collection*

End of Malemute Burn
$t \approx 0.6$ min
Altitude: 52 km

$t \approx 4.0$ min
Altitude: 95 km
*Data Collection*

$t \approx 4.5$ min
Altitude: 75 km
*Data Collection*

$t \approx 7.5$ min
Chute Deploys

$t \approx 15$ min
Splash Down
# Detailed Weight Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Total Mass (lbf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All PCBs and ABS</td>
<td>53g</td>
</tr>
<tr>
<td>ADXL1001Z x3</td>
<td>7.5g</td>
</tr>
<tr>
<td>RTC</td>
<td>2g</td>
</tr>
<tr>
<td>Raspberry Pi 3B</td>
<td>42g</td>
</tr>
<tr>
<td>ADC Pi Hat</td>
<td>18.2g</td>
</tr>
<tr>
<td>ADIS 16460</td>
<td>15g</td>
</tr>
<tr>
<td>UART</td>
<td>4g</td>
</tr>
<tr>
<td>1/8 inch machine Screws x12</td>
<td>181.5g</td>
</tr>
<tr>
<td>¼ in Machine Screws x6</td>
<td>105g</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>428.2g ~ 15 ounces</strong></td>
</tr>
</tbody>
</table>
4.2.0 Design Overview

Ronald Willis
System Changes Since STR

• To save even more space, we are eliminating the ADC board and replacing it with the MCP3208 ADC chip.

• The IC is the IC on the larger board. We don’t need any of the superfluous components on the breakout board, so this change will be an improvement overall.
Design Overview
Design Overview
Functional Block Diagram

- Raspberry Pi
- RBF (Wallops)
- Memory
- ADIS 6 DOF Gyroscope
  - ADXL X-Axis
  - ADXL Y-Axis
  - ADXL Z-Axis
- Real Time Clock
- Raspberry Pi Hat ADC MCP3208
  - Digital Data
  - 3V signal
  - Variable Data
  - 5V signal
  - Telemetry Data
- Telemetry
Hazardous Mechanical Items

• No hazardous components.
Hazardous Electrical Items

• No hazardous components.
Special Requests

• We only request enough room to fit our experiment.
4.3.0 Subsystem Testing Status

Name of Presenter
Evaluation Boards for the Low Noise, High Frequency MEMS ADXL1002 Accelerometer

- 3.3-5.25 volt, 1 mA.
- 2.5 X 3 = 7.5 grams
- Connects to RP Hat.
- Final
- Tested and working.
- Will have to order new ones.
Real Time Clock 277258-VP

- Charged with super cap, battery operated, or powered directly with the Pi.
- Less than 2 grams
- Connects to RP Hat.
- Code is Finished
- Final
- Tested and working.
Raspberry Pi 3B

- Up to 700 mA, but only reached 600 mA during testing without turning off HDMI and Bluetooth. Normal constant Amp range below 500 mA.
- 42 grams
- Connects to RP Hat.
- Final
- System tested and working.
Raspberry PI HAT - 8 Channel ADC - MCP3208 - SPI

- 4.5-5.5 Volts, Low current operation with typical standby and active currents of only 500 nA and 320 µA
- 42 grams
- Connects to Wallops Power.
- 18.1437 grams
- Final
- Tested and working.
ADIS16460

- 3.15 – 3.55 Volts, 44 – 55 mA
  - Connects to RP Hat.
  - 15 grams
  - Final
  - Code is complete.
  - Ordering a Replacement.
4.4.0 Integrated Subsystem Testing Status

Ronald Willis
Integrated Subsystem Testing Status

- Accelerometers will be mounted.
- Gyro will be mounted.
- Board will be inserted.
- Wires will be connected.
- System will be tested with all components attached.

- Below is a picture of the testing system.
Integrated Subsystem Testing Status:
4.5.0 Plan for Full Mission Simulation Review (FMSR)

Ronald Willis
Mechanical Testing

• Mechanical design is essentially complete. All that is required is to verify final dimensions inside of the enclosure.
Electrical Testing

• We discovered a configuration issue with the gyro and the accelerometers. We were not seeing accurate results because we had two pins floating when they needed to be grounded on the ADXL. I am communicating with Analog Devices application engineers to properly configure the single pin we are having issues with on the gyro. That pin is the reset pin.
Software Testing

• The code is pretty much the same as last review. Walter has made pretty substantial leaps and bounds, but until we properly assign the last pin on the gyro, the code will be at the stage it is currently.
System Level Testing

• We have our testing system at the school ready for the new pin configuration. The applications engineer should be getting back to me by Monday of this upcoming week on the gyro.
Plan for FMSR

• The plan is to work with the applications engineer over this week to verify the pins are connected to the proper outlet and then to test the new configuration. Only 1 pin needs configuring and we are easily able to communicate with the rest of the devices.
4.6.0 Project Schedule

Ronald Willis
Schedule

• Finish verifying correct electronics hook up.
• Test new set up.
• Polish the code.
• Generate 3D models.
• Create 3D environment.
June Operations

• Our system only needs power. It is designed to automatically collect data until power off.
June Operations

• Payload will be complete and ready.
June Operations

• All systems should be operational.
4.7.0 Project Management

Ronald Willis
Picture
Payload Special Operations/Inhibits

• As long as the enclosure has enough space for our mounted parts, we will have no more requirements.
## Latest Contact Matrix

### BRCTC Space Team/Blue Ridge Community & Technical College

#### Fall 2018 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>BRCTC Advisor</td>
<td>Gervase Willis</td>
<td>(304)-596-4091</td>
<td>(304)-596-4091</td>
<td>Yes</td>
<td><a href="mailto:gwillis@blueridgectc.edu">gwillis@blueridgectc.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>BRCTC Advisor</td>
<td>David Teets</td>
<td>(540)-325-4651</td>
<td>(540)-325-4651</td>
<td>Yes</td>
<td><a href="mailto:dteets@blueridgectc.edu">dteets@blueridgectc.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>BRCTC Assistant</td>
<td>Adam Bridendolph</td>
<td>(304)-260-4380</td>
<td>(304)-260-4380</td>
<td>Yes</td>
<td><a href="mailto:abridend@blueridgectc.edu">abridend@blueridgectc.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>BRCTC Team Lead</td>
<td>Ronald Willis</td>
<td>(717)-357-6172</td>
<td>(717)-357-6172</td>
<td>Yes</td>
<td><a href="mailto:rwilli12@my.blueridgectc.edu">rwilli12@my.blueridgectc.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
</tbody>
</table>
4.8.0 Conclusions

Ronald Willis
Worries and Concerns

- Our biggest worry comes from enclosure dimensions being correct for our mounted parts.
5.0.0 WVU

Integrated Subsystem Testing Review (ISTR)

West Virginia University
Team Lead: Clayton Cobb
   Danel Ligon
   Brian Frongello
   Justin Bowman
   Clayton Cobb
   03/16/2020
3.1.0 Mission Concept and Interfaces

Justin Knotts
Dr. Tracey DeLaney
Mission Overview: Mission Statement

- Provide Training for Undergraduate Students (and new faculty mentor) in building and assembling spacecraft payloads
- Use a Raspberry Pi, two speakers and a microphone to measure the transmission of pressure waves
- Create a neat PR opportunity to go with launch videos
Success Criteria

MINIMUM SUCCESS CRITERIA:
– Audio recorded successfully at the beginning of flight

COMPREHENSIVE SUCCESS CRITERIA:
– Active sounds recorded at sufficient fidelity over background to track thermal and pressure variations from 1 atm => ~0 and from ~0 => 1atm
WVWC ConOps

- All systems on
- Begin data collection

Apogee
- $t \approx 3.1\, \text{min}$
- Altitude: $\approx 150\, \text{km}$

End of Malemute Burn
- $t \approx 0.6\, \text{min}$
- Altitude: 52 km

- Chute Deploys
- $t \approx 7.5\, \text{min}$

- Splash Down
- $t \approx 15\, \text{min}$
Activation Sequence: WVWC

- WVWC Timer Events

<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>flight</td>
<td>WVWC experiment powers on, initialized in time to measure forces at launch</td>
</tr>
</tbody>
</table>
5.2.0 Design Overview
System Changes Since STR

• Students have built and tested system.
• Can Create and record sounds
  – Still need to be more specific about which sounds
  – Still need better onboard processing (if possible)
Design Overview: Engineering Design

• Main Controller: Raspberry Pi Zero
  – Mounted wherever convenient for space, weight, connectivity

• Sound Interface: ReSpeaker 2-Mics Pi HAT
  – Has two built-in microphones
  – Connect two speakers directly to Pi HAT
  – Mount microphone/Pi HAT near center of deck
  – Speakers near edges
Functional Block Diagram

Speaker A

ReSpeaker 2-Mics Pi HAT (with microphones)

Main Controller (Raspberry Pi Zero?)

Speaker B

5V Rail
### Example Sat Power Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Voltage (V)</th>
<th>Current (A)</th>
<th>Time On (min)</th>
<th>Amp-Hours</th>
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</thead>
<tbody>
<tr>
<td>Pi</td>
<td>5</td>
<td>.250A</td>
<td>60</td>
<td>0.250</td>
</tr>
<tr>
<td>Pi hat</td>
<td>5v</td>
<td>0.0004A</td>
<td>60</td>
<td>0.0004</td>
</tr>
</tbody>
</table>

Total (A*hr): 0.2504

Over/Under 0.7496
Hazardous Mechanical Items

• None
Hazardous Electrical Items

• None
Special Requests

• None
5.3.0 Subsystem Testing Status
Subsystem Testing Status

Subsystem WVU

Pi Zero Creating and recording sounds
  (enough for successful flight, but more would be better)
Need to better ‘chirp’ the sounds
Test onboard processing
5.6.0 Project Schedule
WVU – Schedule

- March, 2020 – Update software
- April, 2020 – Test in varying environments
- May, 2020 – Final Integration with WVSFDC.
June Operations

- WVU: everything should be good to go.
5.8.0 Conclusions
Conclusion

• Covid-19?
  – Not sure how to best handle the fact that undergraduates are not to be on campus.
    • May purchase a backup piece of equipment (personal money) and send to specific team members. Then use a git repository to handle version control
Appendix