Temet Nosce

McNeese State University

**Integrated Subsystem Testing Review**

Kevin Romero
Michael Casteel
Matthew Williams
Logan Gilmore
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Mission Overview
Kevin Romero
Michael Casteel
Matthew Williams
Logan Gilmore
Mission Overview: Mission Statement

**Mission Statement**

- **Temet Nosce's** mission is to design and construct a multi-method Cosmic Ray Detector, capable of surviving the treacherous journey to space and back.
- During the payload's intense journey it will capture and record detection events of various forms of radiation.
- Using the multi-method approach the team can utilize a coincidence circuit as well as software to filter the data and more effectively determine the detected particle's identity, whereas, with a single scintillator it's impossible to be as precise.
- After screening of data, flux density of detected Cosmic Rays vs. altitude will be determined.
Mission Overview: Theory and Concepts Continued

• **Methods of Detection**
  - Two Scintillators, EJ-200 and EJ-208, in coincidence
  - Geiger Counter
  - Raw data is obtained from each individual detector as well as the coincidence circuit
  - Data will be analyzed to determine which radiation is the most likely cause of detection events
  - The focus of our experiment is radiation of Cosmic Ray origin
  - Will also be able to use data analysis to plot other detected forms of radiation vs. altitude
Mission Overview: Theory and Concepts Continued

• **Coincidence Circuit**
  - Two Scintillators, EJ-200 (BC-408) and EJ-208 (BC-412), in coincidence
  - Produces additional data set when both scintillators detect radiation simultaneously

<table>
<thead>
<tr>
<th>Radiation Detected</th>
<th>BC-400</th>
<th>BC-404</th>
<th>BC-408</th>
<th>BC-412</th>
<th>BC-416</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;100keV X-rays</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100keV to 5MeV gamma rays</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>&gt;5MeV gamma rays</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fast neutrons</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Alphas, betas</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charged particles, cosmic rays, muons, protons, etc.</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
• **Geiger Counter**
  - Detects Ionizing Radiation.
  - LND 712 – designed to detect Alpha, Beta, and Gamma radiation.
    - Also can detect cosmic rays
  - Will be used to help better understand the context of the radiation the payload encounters.

Mission Overview: Concept of Operations

**Data collection – when are we collecting data?**
- T-3 minutes before launch to when our SS relays are deactivated by the master microcontroller.

**Altitudes of interest – what altitudes are you looking for specific data?**
- All altitudes.
- Expecting higher altitudes to provide us with more counts of Cosmic Rays than lower altitudes.

**When does your payload stop collecting data? When does it turn off?**
- Master microcontroller deactivates the two SS relays 30 minutes after circuit activation.
- All circuit elements downstream of the relays will no longer receive current flow after this has occurred.
- The master microcontroller's and battery #2's current flow will cease when the WFF relay is opened.
Mission Overview: Concept of Operations Continued

Payload Operation vs. Rocket Flight

- Altitude (a)
  - 120 km
  - 110 km
  - 100 km
  - 90 km
  - 80 km
  - 70 km
  - 60 km
  - 50 km
  - 40 km
  - 30 km
  - 20 km
  - 10 km
  - 0 km

- Time (t)
  - t=27 min
  - Payload Auto Powered OFF
  - (master microcontroller turns payload off)
  - t=5.5 min
  - Parachute Deploys
  - t=15 min
  - Splashdown
  - t=0 min
  - Payload Powered ON
  - (beginning of data collection)

- Apogee
  - (a=115 km)

Primary Cosmic Rays become major component of measurement.

Secondary Cosmic Rays are major component of measurement.
Success Criteria

• **Minimum Success Criteria**
  ➢ The minimum amount of data collected will have to be continuous collection from launch to apogee. This will allow our team to draw conclusions with all altitudes accounted for. If there is breaks in the data set due to technical errors, this may change the view of success.

• **Comprehensive Success Criteria**
  ➢ To achieve full success we will need continuous data collection from launch to landing. This will give us a more reliable data set to analyze since every altitude will be accounted for twice. Data will need total continuity to be considered comprehensive.
Changes since STR

• Power and Data Processing/Archive subsystem
  ➢ Moved location of SS Relay.
  ➢ Rotated microcontrollers 180 degrees.
  ➢ Swapped polarity of batter terminals.
  ➢ Added battery bolt holes.
  ➢ Enlarged battery holder terminal holes.

• Geiger Counter
  ➢ PCB design updates:
    • Larger holes for Geiger tube lacing.
    • More compact design.
    • MOSFET transistor footprint fixed.

• Scintillator/SiPM subsystem
  ➢ Removed R4.
  ➢ Adjusted R18 and R19.
  ➢ Moved C7 and C18 grounds.
  ➢ Moved Schmitt Trigger reference voltage to its respective Scintillator/SiPM microcontroller.
Changes since STR

• **Software**
  - Completed post-analysis automation for conversion of counts per minute
    ▪ (includes script debugging)
  - Moved data graphing to Python from Excel

• **Mechanical subsystem**
  - Payload construction has been completed
  - Neoprene added to replace standoffs
  - Ballast has been completed and installed
Design Overview

Kevin Romero
Michael Casteel
Matthew Williams
Logan Gilmore
System Definitions

• CFO: Chief Financial Officer
• SE: Software Engineer
• STR: Structural
• EPS: Electrical and Power Systems
• SiPM: Silicone Photomultiplier
• GM: Geiger Muller
• MCU: Microcontroller Unit
• PCB: Printed Circuit Board
• CAD: Computer Aided Design
• ISR: Interrupt Service Routine
System Level Block Diagram
Final Design Description – Mechanical
Final Design Description – Exterior Dimensions
Final Design Description – Interior Dimensions

- Bolt holes for the closing wall to attach to
- Guides for each layer to slide into

Dimensions:
- 9.53 mm
- 3.18 mm
- 1.59 mm
Final Design Description – Indicator Panel Dimensions

Ø 5.0 mm
Final Design Description – Plate Dimensions

- Mounting holes for PCB’s
- Wiring Channel

Dimensions:
- Length: 152.40 mm
- Width: 152.40 mm
- Radius: R12.70 mm
Final Design Description—Layer 1 Dimensions
Final Design Description – Layer 2 Dimensions
Final Design Description – Layers 3 & 4 Dimensions
Final Design Description – Layer 5 Dimensions

- 4X Ø3.3 mm
- Geiger Counter / Mounting
- 4X Ø2.4 mm
- Capacitors
- Transformer
- Resistors
- Connector

- 15.10 mm
- Ø14.10 mm
- 5.00 mm
Final Design Description – Layer 5 Dimensions
Final Design Description – Design in Canister (Shared)
## Final Design Description – Mass Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Total Mass (lbf)</th>
<th>Total Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>½ Canister</td>
<td>3.35</td>
<td>1.52</td>
</tr>
<tr>
<td>½ Mid Plate</td>
<td>0.75</td>
<td>0.34</td>
</tr>
<tr>
<td>Main Housing</td>
<td>1.879</td>
<td>0.852</td>
</tr>
<tr>
<td>Closing Wall</td>
<td>0.336</td>
<td>0.152</td>
</tr>
<tr>
<td>Plates</td>
<td>0.651</td>
<td>0.295</td>
</tr>
<tr>
<td>Guides</td>
<td>0.310</td>
<td>0.141</td>
</tr>
<tr>
<td>Layer 1</td>
<td>0.46</td>
<td>0.21</td>
</tr>
<tr>
<td>Layer 2</td>
<td>0.185</td>
<td>0.084</td>
</tr>
<tr>
<td>Layer 3 &amp; 4</td>
<td>0.825</td>
<td>0.374</td>
</tr>
<tr>
<td>Layer 5</td>
<td>0.187</td>
<td>0.085</td>
</tr>
<tr>
<td>Ballast (At Center)</td>
<td>1.142</td>
<td>0.492</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10.075</strong></td>
<td><strong>4.54</strong></td>
</tr>
<tr>
<td><strong>Under/Over</strong></td>
<td><strong>0.075</strong></td>
<td><strong>0.03</strong></td>
</tr>
</tbody>
</table>
## Final Design Description – Materials of Construction

<table>
<thead>
<tr>
<th>Item #</th>
<th>Name</th>
<th>Qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3/8&quot; x 3/8&quot; x 1/16&quot; Angled Aluminum - 8'</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Main Housing</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Closing Wall</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Trays</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>1/8&quot; x 3/16&quot; Grip Blind Rivets - 100 ct.</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>#4-40 Bolts</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>#4-40 Nylon Lock Nuts</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Vinyl Tubing 1/8&quot; ID - 1 ft</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>#8-32 Bolts</td>
<td>20</td>
</tr>
<tr>
<td>9</td>
<td>#2-56 Bolts</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>#2-56 Nuts</td>
<td>20</td>
</tr>
<tr>
<td>11</td>
<td>Flat Aluminum Bar 1/16&quot; x ¾ &quot; x 8'</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>#6-32 Bolts</td>
<td>8</td>
</tr>
<tr>
<td>13</td>
<td>#6-32 Nylon Lock Nut</td>
<td>8</td>
</tr>
<tr>
<td>14</td>
<td>1/8” x 2” x 4’Steel Bar</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>1/8” x 1/2” x 4’ Steel Bar</td>
<td>1</td>
</tr>
</tbody>
</table>
Subsystem Status

Kevin Romero
Michael Casteel
Matthew Williams
Logan Gilmore
Electrical Subsystem Status

Power

Kevin Romero

Testing Status

100%
Changes Since STR

• **SS Relay for battery #1 was relocated in order to switch on/off the connection between the negative terminal of the battery and buck converter.**

• **Flipped orientation of battery terminals to accommodate proper battery holder interfacing.**

• **Enlarged battery holder pin holes and pads to improve battery holder interfacing.**

• **Microcontrollers were rotated 180 degrees to allow easier access to SD cards.**

• **Bolt holes were added to PCB for battery holders.**
Power and Data Processing/Archive PCB Design
Power : Testing Results

- Applied 9V to input of Buck Converter with DC power supply and measured 5.16V on output.
- Attached 9V battery to input of Buck Converter and measured 5.16V on output.

  - This test proves the Buck Converter’s capability of stepping down the 9V battery input to the ~5V required to power our microcontrollers.

- Used Buck Converter to power microcontrollers.

  - Proves the Power subsystem can supply reliable power to at least the four microcontrollers.

- While powered by the Buck-Converter used microcontrollers to power their individual circuits and checked for proper voltage.

  - Proves that while powered by the Buck Converter, the microcontrollers can supply power to their circuits successfully.
Power : Testing Results

✓ Used Buck Converter with 9V battery supply to power entire Scintillator/SiPM Electrical subsystem. Current draw on Battery #1 was measured.

- This demonstrated the battery #1 can supply proper current to power its electrical subsystems.
Activated Power subsystem and allowed 30 minutes to elapse.

- Upon circuit activation, the Master microcontroller successfully turned on the SS relays which allowed current to flow through battery #1 and power its subsystems. Current flow was correctly indicated by battery #1 Power indication LED.

- After 30 minutes elapsed the Master microcontroller successfully turned off SS relays and current flow ceased from battery #1. The Power indication LED turned off.

- This test proves the Master microcontroller can turn on and off the downstream subsystems as designed.
Electrical Subsystem Status

Geiger Counter

Logan Gilmore

Testing Status

100%
Changes Since STR

• What major changes have you made since the STR?
  ➢ PCB design updates:
    • Larger holes for Geiger tube lacing.
    • More compact design.
    • MOSFET transistor footprint fixed.

• Do these change any of your mission objectives/requirements?
  No, these changes do not affect our mission objectives/requirements.
Old Board Vs. New Board
✓ Converts the DC signal from RELAY_2_OUT into a stable, high frequency digital signal.

✓ Output amplitude is 326mV with a minimum of –152mV and a maximum of 198mV, signifying high and low for proper oscillation.

– Test point is connected before the transformer to ensure frequency closely matches the required 23kHz.

### Oscillator Sub-Circuit: Testing Results

<table>
<thead>
<tr>
<th>Type</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Voltage (test point)</td>
<td>5.15V</td>
</tr>
<tr>
<td>*AC Voltage (test point)</td>
<td>7.3V</td>
</tr>
<tr>
<td>Frequency (test point)</td>
<td>23.84kHz</td>
</tr>
<tr>
<td>Current Draw</td>
<td>1.71mA @5.13V</td>
</tr>
</tbody>
</table>

*DC Voltage measurement is the voltage supply.*
High Voltage Regulation Sub-Circuit: Testing Results

- Converts the oscillating signal produced by the oscillator sub-circuit into a high voltage oscillating signal.
- Zener diodes properly only allow 500V to pass through.
- Provides this 500V signal to the Geiger Muller tube.
  - Test point is connected to the signal entering tube to ensure the proper voltage supply.

<table>
<thead>
<tr>
<th>Type</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>*DC Voltage (test point)</td>
<td>252V</td>
</tr>
<tr>
<td>AC Voltage (test point)</td>
<td>260mV</td>
</tr>
<tr>
<td>Current Draw</td>
<td>33.98mA @5.13V</td>
</tr>
</tbody>
</table>

*252V DC Voltage is sufficient for operation.
Geiger Muller Tube: Testing Results

✓ **Produced voltage pulses of adequate amplitude corresponding to ionizing radiation detected.**

- *The test point is connected to the tube's output to analyze its voltage pulses.*

<table>
<thead>
<tr>
<th>Type</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>*DC Voltage (test point)</td>
<td>-3mV Idle and 17.61mV Pulse</td>
</tr>
<tr>
<td>AC Voltage (test point)</td>
<td>274mV</td>
</tr>
</tbody>
</table>

*Pulse voltage should be near this value to ensure a count is triggered.*
Generates rectangular pulses corresponding to the voltage pulses received from the Geiger Muller tube actuation.

Signifies a count when the rectangular wave is high (3.3V).

Input frequencies of up to 100Hz closely match the corresponding output frequency showing that this sub-circuit can adequately support more than enough count volume.

<table>
<thead>
<tr>
<th>Type</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Voltage</td>
<td>3.29V</td>
</tr>
<tr>
<td>Current Draw</td>
<td>2.99mA @5.13V</td>
</tr>
</tbody>
</table>
Geiger Counter Full-Circuit: Testing Results

✓ Successfully detects alpha, beta, and gamma ionizing radiation while meeting expected count rates at ground level.
✓ Detection LED and speaker accurately correspond to counts received.

<table>
<thead>
<tr>
<th>Type</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Draw w/o MMC and Switches</td>
<td>49.0mA @5.20V</td>
</tr>
<tr>
<td>Current Draw w/ MMC and Switches</td>
<td>112mA @5.20V</td>
</tr>
</tbody>
</table>
Electrical Subsystem Status
Scintillator/SiPM Detector

Kevin Romero

Testing Status

100%
Changes Since STR

- R4 was removed to drop the output voltage of the DC/DC Converters from ~29.8 volts to ~29 volts.
- R18 has been adjusted to 133k ohms to adjust switching voltage of Schmitt Trigger.
- R19 has been adjusted to 156k ohms to adjust switching voltage of Schmitt Trigger.
- The Schmitt Trigger reference voltage is now provided by its respective Scintillator/SiPM microcontroller instead of the Coincidence microcontroller.
- Moved the ground of the C7 and C18 capacitors to the ground of its respective DC/DC Converter.
Changes Since STR
Both DC/DC Converters were tested by applying power to their respective microcontroller and measuring the output.

-This test shows us the DC/DC converters were soldered successfully, work, and can supply the required voltage range needed to power the SiPM sensors.
Both amplifier were tested by applying a signal using an arbitrary function generator and viewing the output with an oscilloscope. A sine wave was applied to the input. The expected wave and gain was viewed on the output using an oscilloscope.

- This test was performed to verify that we will receive the expected amplification of the SiPM output when a detection event occurs.
Both peak detectors were tested by using an arbitrary function generator to apply a sine wave to the input. The expected slowed rate of signal decay was observed at the peak detector’s output.

- This test was performed to verify that we could slow the rate of signal decay in order for the microcontrollers to have enough time to take an ADC measurement of the signal.
The inverting Schmitt Triggers were tested by applying a sine wave to the input of its respective amplifier and observing the output of the Schmitt trigger via an oscilloscope.

The expected digital output was captured on the output of the inverting Schmitt Trigger.

- This test was performed to verify proper function and expected transitions of the inverting Schmitt Trigger.
Software Subsystem Status
Data Processing/Archive

Michael Casteel

Testing Status

100%
Changes Since STR

• What major changes have you made since the STR?
  ➢ Completion of automatic scripts for processing data into counts per minute
    ▪ Fixed minor bugs in the scripts relating to data processing limitations
  ➢ Movement of graph creation from Excel to Python "MatPlotLib"
  ➢ Research into relationship between particle energy and SiPM subsystem milliampere signal

• Do these change any of your mission objectives/requirements?
  ➢ No, changes are for optimization and objective fulfillment
Data Processing/Archive: Post-Collection Testing

Formula for Standard Error of the Estimate: 
\[ \sigma_{est} = \sqrt{\frac{\sum(Y - Y')^2}{N}} \]

*Error Bounds* = \( \pm 2 \cdot \sigma_{est} \)

<table>
<thead>
<tr>
<th>Method</th>
<th>Savitzky-Golay</th>
<th>Derivative Savitzky-Golay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>25</td>
<td>53</td>
</tr>
<tr>
<td>Error Bound +/-</td>
<td>2.094</td>
<td>2.218</td>
</tr>
<tr>
<td>Bound % Confidence</td>
<td>95.97</td>
<td>95.64</td>
</tr>
</tbody>
</table>

*Constant polynomial of order 3 used*

<table>
<thead>
<tr>
<th>Method</th>
<th>Pre-Derivative Univariate Spline</th>
<th>Post-Derivative Univariate Spline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoothing Factor</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Error Bound +/-</td>
<td>1.336</td>
<td>1.638</td>
</tr>
<tr>
<td>Bound % Confidence</td>
<td>96.64</td>
<td>94.63</td>
</tr>
</tbody>
</table>
Data Processing/Archive: Integrated Subsystem Testing Results
Data Processing/Archive: Integrated Subsystem Testing Results

Sintillator and Coincidence Count Rates

Counts Per Minute

Minutes

Scintillator 1
Scintillator 2
Coincidence
Data Processing/Archive: Integrated Subsystem Testing Results

✓ 30 Minute Test Data: Geiger Counter
Data Processing/Archive: Integrated Subsystem Testing Results

30 Minute Test Data: EJ 200
Data Processing/Archive: Integrated Subsystem Testing Results

✓ 30 Minute Test Data: EJ 208
Data Processing/Archive: Integrated Subsystem Testing Results

✓ **30 Minute Test Data: Scintillator Coincidence**
Mechanical Subsystem Status

Payload Structure

Matthew Williams

Testing Status

100%
Changes Since STR

• Payload construction has been completed
• Neoprene added to replace standoffs
• Ballast has been completed and installed
Payload Structure: Block Diagram
Payload Structure: Testing Results

- Design configuration that provides enough space for each component, while also staying within the required height of the canister.
  - This can be seen in the final design description (16-25), some heights of each layer may change during fabrication so the height between layers may be adjusted, but the overall height will remain at 4.5”

- Calculate weight of each layer to further improve FEA.
  - This can be seen on Slide 27 and will apply to the FEA on the next slides
Payload Structure: Testing Results

✓ Add plates into FEA and apply weights calculated in the weight budget.

**Top Mounting Only**

- The maximum Von Mises Stress is located on the back right mounting hole with a value of 7.2 ksi. This yields a safety factor of 5.6
Payload Structure: Testing Results

Top & Bottom Mounting

- The maximum Von Mises Stress is located on the back right mounting hole with a value of 2.3 ksi. This yields a safety factor of 17.4
Payload Structure: Testing Results

✓ Calculate center of mass based on housing and component weight.

\[ x_{cg} = \frac{m_1 g x_1 + m_2 g x_2 + m_3 g x_3}{(m_1 g + m_2 g + m_3 g)} \]

- The coordinates calculated can be seen below. Inventors built in COG feature also displays similar results. This is well within the 1x1x1 in requirement of RockSat-C.

\[ x_{cg} \approx -0.28'' \quad y_{cg} \approx -0.16'' \quad z_{cg} \approx 0.02'' \]
Design any other elements that will be needed to support other systems.

- An extra structural item designed was a plastic mount to help reduce stress on the Geiger Muller tube. This design and FEA can be seen below.
Integrated Subsystem Testing Status

Kevin Romero
Logan Gilmore
Michael Casteel
Matthew Williams
## Integrated Subsystem Testing Status

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Use Power subsystem to power the Scintillator/SiPM and Geiger Counter subsystems.</td>
<td>100%</td>
</tr>
<tr>
<td>2</td>
<td>Use Power and Data Processing/Archive subsystem to power and collect data from the Scintillator/SiPM and Geiger Counter subsystems.</td>
<td>100%</td>
</tr>
<tr>
<td>3</td>
<td>Run 30 minute test. Analyze the data obtained, verify the expected count rates, and produce graphs.</td>
<td>100%</td>
</tr>
<tr>
<td>4</td>
<td>Install all electrical subsystem into payload housing. Repeat steps 1-3.</td>
<td>100%</td>
</tr>
<tr>
<td>5</td>
<td>Remove 30-minute time constraint to test battery life and performance limits.</td>
<td>100%</td>
</tr>
</tbody>
</table>
Integrated Subsystem Testing Status

✓ Test: Use Power subsystem to power the Scintillator/SiPM and Geiger Counter subsystems.

- This test proves the Power subsystem can successfully power all electrical subsystems.
Test: Use Power and Data Processing/Archive subsystem to power and collect data from the Scintillator/SiPM and Geiger Counter subsystems.

- This test proves the Power and Data Processing/Archive subsystem can successfully power and collect/store data from the electrical subsystems.
Integrated Subsystem Testing Status

Test: Run 30 minute test. Analyze the data obtained, verify the expected count rates, and produce graphs.

- This test proves the Power and Data Processing/Archive subsystem can power and collect/store data from the electrical subsystems long enough to achieve mission success.

- If obtained count rates match the expected rates, this test proves the sensors have been calibrated correctly.

- This test allows the team to visualize the data obtained and refine our data analysis process.
Integrated Subsystem Testing Status

✓ Test: Install all electrical subsystem into payload housing. Repeat steps 1-3.

- This test proves the electrical subsystems will fit within/on the payload housing and still obtain the expected data.

- All electrical subsystems were installed on/in the payload housing and received the same count rates as observed before installation.
Integrated Subsystem Testing Status

✓ Test: Remove 30-minute time constraint to test battery life and performance limits.

- This test demonstrates how long the Power subsystem can effectively supply power to the payload with fresh batteries.

- With new batteries and our current power plan the Power subsystem can reliably power all electrical subsystems for a total of 6 flights.
Plan for Full System Integration

Matthew Williams
Kevin Romero
Michael Casteel
Logan Gilmore
Canister Integration

- **Payload will be placed into top side of canister with any orientation acceptable.**
- **4 #8-32 bolts will be inserted into the top bolt holes and will be secured with nylon lock nuts from the interior of the housing.**
- **To test that this will be successful, we will verify all measurements based on canister drawings and then construct mock plating to test the interfacing.**
Vibe Test

- **Neoprene Pads installed above and below the payload to help absorb some of the vibrations occurring.**

- **Nylon lock nuts and neoprene washer are the primary fasteners used to also help reduce vibration reaching all components.**

- **We will utilize a shaker to test our payload prior to arriving at WFF.**
Electrical Testing

• Power Subsystem:
  ➢ Activate WFF activation line and measure voltages going to each subsystem.
  ➢ Verify power indication LEDs correctly indicate current flow status.
  ➢ Verify that after 30 minutes has elapsed all current flow downstream of SS relays ceases.
  ➢ Install new batteries, remove 30 minute time constraint, test the limits of power supply duration.

• Geiger Counter Subsystem:
  ➢ Ensure High Voltage Regulation sub-circuit components and Gieger Muller tube are not in close contact with anything metal to prevent arching or shorting.
  ➢ Activate the Power subsystem and verify the approximate 5V input on RELAY_2_OUT.
  ➢ Measure test points and ensure the measurements are as expected under operating condition.
  ➢ Ensure LED and speaker accurately correspond to counts received.
  ➢ Ensure count rate at ground level matches expected results.
**Electrical / Software Testing**

- **Scintillator/SiPM Subsystem:**
  - Activate the Power subsystem, verify DC/DC converter voltages are within the correct range.
  - Apply signal to the output of the SiPM connector (input of the amplifier circuit).
  - View output signal of amplifier, peak detector, and Schmitt Triggers.
  - Repeat for both Scintillator/SiPM circuits.
  - Connect the Scintillator/SiPM combinations. Verify correct count indication LED blink frequency.

- **Data Processing / Archival Subsystem:**
  - Run payload, verifying that LED's blink at a reasonable rate
  - Remove microSD storage medium and retrieve data
  - Check data for integrity and completeness
  - Analyze raw data for anomalies, and clean up any small outliers
    - (I.E: removing beginning log line, removing any data points after the deactivation period)
  - Process raw data through post-analysis script
  - Analyze resulting charts and data spreadsheets for reasonableness
  - Make conclusions from results
# System Level Testing Plan

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mount all Electrical Subsystems onto trays.</td>
<td>Matthew</td>
<td>Prior to 3/31/2020</td>
<td>McNeese State University</td>
</tr>
<tr>
<td>2</td>
<td>Measure height of each layer to ensure initial height assumptions will work.</td>
<td>Matthew</td>
<td>Prior to 3/31/2020</td>
<td>McNeese State University</td>
</tr>
<tr>
<td>3</td>
<td>Order aluminum housing for payload.</td>
<td>Matthew/Logan</td>
<td>Prior to 3/31/2020</td>
<td>McNeese State University</td>
</tr>
<tr>
<td>4</td>
<td>Install brackets into proper locations to allow each layer to have enough room.</td>
<td>Matthew</td>
<td>Prior to 3/31/2020</td>
<td>McNeese State University</td>
</tr>
<tr>
<td>5</td>
<td>Insert trays into payload housing.</td>
<td>Matthew</td>
<td>Prior to 3/31/2020</td>
<td>McNeese State University</td>
</tr>
<tr>
<td>6</td>
<td>Connect all Electrical Subsystem interface connectors and LEDs.</td>
<td>Kevin/Logan/Michael</td>
<td>Prior to 3/31/2020</td>
<td>McNeese State University</td>
</tr>
<tr>
<td>7</td>
<td>Measure voltage on each layers provided test points. Verify expected readings.</td>
<td>Kevin/Logan</td>
<td>Prior to 3/31/2020</td>
<td>McNeese State University</td>
</tr>
<tr>
<td>8</td>
<td>Close front panel and verify LEDs indicate correct current status.</td>
<td>Team</td>
<td>Prior to 3/31/2020</td>
<td>McNeese State University</td>
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## System Level Testing Plan Continued

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<tr>
<td>9</td>
<td>Verify blinking frequency of detection LEDs matches expected count rate.</td>
<td>Michael</td>
<td>Prior to 3/31/2020</td>
<td>McNeese State University</td>
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<tr>
<td>10</td>
<td>Verify voltage difference between payload structure and ground is 0V.</td>
<td>Kevin</td>
<td>Prior to 3/31/2020</td>
<td>McNeese State University</td>
</tr>
<tr>
<td>11</td>
<td>Allow system to collect data for ~30 minutes. Extract data and verify expected results.</td>
<td>Michael</td>
<td>Prior to 3/31/2020</td>
<td>McNeese State University</td>
</tr>
<tr>
<td>12</td>
<td>Weigh the integrated payload to ensure it falls within required weight envelope</td>
<td>Matthew</td>
<td>Prior to 3/31/2020</td>
<td>McNeese State University</td>
</tr>
</tbody>
</table>
Plan for FMSR

• All systems have been integrated and tested.
• Everything done from this point on will be strictly cosmetic or related to the post-flight data analysis process.
• In order to conduct a “Full Mission Simulation” all we require now is the canister.
• Once the payload is installed on the canister FMSR will be very similar to tests already conducted.
• No large hurdles are expected from this point on.
Shared Can Logistics
Michael Casteel
Matthew Williams
Shared Can Logistics

Teams Temet Nosce and The Excelsiors will share a canister

- Temet Nosce of McNeese State University is developing a multi-method cosmic ray detector.
- The Excelsiors of Temple University will develop a payload to collect air samples via atmospheric port at varying altitudes during flight to evaluate ozone and CFC levels in a lab post-flight.

How are you communicating and sharing designs?
- Temet Nosce team members will communicate over email with The Excelsiors to share files and communicate any needed information.

Any actual fit checks before June?
- Due to current situations, cooperative test fit is unlikely.
Shared Can Logistics

Are you mounting to the top of the bottom? Are you using a mid mounting plate?
• Temet Nosce will mounting to the top of the canister. Through communications with the Excelsiors, it appears that we will be utilizing a mid mounting plate.

What is your combine mass, with canister/mid-mounting plate included?
• The combined masses of our payloads is approximately 18.3 lbs. There will need to be collaboration with the Excelsiors to ensure we increase our weight to the appropriate amount.

Who needs what port?
• The Excelsiors will require the atmospheric port, but we will require none.
User Guide Compliance
Kevin Romero
Matthew Williams
### Electrical Requirement

<table>
<thead>
<tr>
<th>Requirement</th>
</tr>
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<tbody>
<tr>
<td>Must provide at least 1 set of 2 wires for payload activation (must be Teflon insulated), at or thinner than 24 AWG and at least 4’ long</td>
</tr>
<tr>
<td>24 AWG Stranded</td>
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<tr>
<td>Set of wires conforming to 1SYS.1 does not exceed 1A</td>
</tr>
<tr>
<td>Currently drawing 412.2 mA</td>
</tr>
<tr>
<td>1SYS.1 shall not latch. WFF will always know if circuit is active or inactive</td>
</tr>
<tr>
<td>SS relay will deactivate upon opening of WFF relay. External LEDs will indicate current status</td>
</tr>
<tr>
<td>All connectors and IC sockets should be tied and staked used RTV sealant or hot glue</td>
</tr>
<tr>
<td>Nylon lacing and hot glue will be used</td>
</tr>
<tr>
<td>No always-on components</td>
</tr>
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<td></td>
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<tr>
<td>No use of radio transmission</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>No high voltage components</td>
</tr>
<tr>
<td>Will apply conformal coating to Geiger Counter DC-DC Converter voltage will stay at ~29V</td>
</tr>
<tr>
<td>Payload must be completely electrically isolated from the canister.</td>
</tr>
<tr>
<td>No electrical components will contact payload structure. Will verify when system is fully integrated.</td>
</tr>
<tr>
<td>Battery type</td>
</tr>
<tr>
<td>Non-rechargeable lithium ion</td>
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</table>
## Mechanical Requirement

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Status/Reason (if needed)</th>
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</thead>
<tbody>
<tr>
<td>Total mass of payload within proper envelope of 5.8 lbs–6 lbs.</td>
<td>Originally was underweight but a ballast will be installed at the center of the payload to overcome the additional weight.</td>
</tr>
<tr>
<td>Volume must allow payload to fit within half of the RockSat-C canister.</td>
<td>Current design fits well into half of the canister (verified with CAD drawings) with a height of 4.5&quot; and a square diagonal of 8.84&quot;.</td>
</tr>
<tr>
<td>Center of gravity falls within a 1 x 1 x 1 inch envelope of the geometric centroid.</td>
<td>Due to the mass of the housing being much higher than the components, the current centroid is well within the envelope required. This should remain as long as the housing is symmetric.</td>
</tr>
<tr>
<td>Payload must bolt to bottom and mid bulkhead with at least 8 out of the 10 possible bolts.</td>
<td>The current payload design has enough bolt holes to utilize all 10 locations. We are currently intending to use at least 8.</td>
</tr>
<tr>
<td>Payload must be able to withstand 25 G's in the positive Z direction during ascent and about +/- 10 Gs in the X and Y axes.</td>
<td>All simulations have shown that these G-Forces will not pose a threat to the integrity of the housing.</td>
</tr>
<tr>
<td>Payload material should be made of SCC materials and have minimum petroleum-based materials</td>
<td>The housing will be made almost entirely of Aluminum 6061, if any petroleum-based materials are needed, they will be used sparingly.</td>
</tr>
</tbody>
</table>
Project Management

Kevin Romero
Matthew Williams
Michael Casteel
Temet Nosce

McNeese State University

(From Left to Right: Dr. Steven Stinnett, Michael Casteel, Logan Gilmore, Kevin Romero, Matthew Williams, and Dr. Zhaung Li)
### Winter Break Schedule

<table>
<thead>
<tr>
<th>TASK</th>
<th>ASSIGNED TO</th>
<th>PROGRESS</th>
<th>START</th>
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<tbody>
<tr>
<td>Finalize Circuit Board Design</td>
<td>Kevin/Logan</td>
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<td>12/7/19</td>
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<td>Order Circuit Boards</td>
<td>Kevin/Logan</td>
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<tr>
<td>Finalize Flight Software</td>
<td>Michael</td>
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<td>12/7/19</td>
<td>1/13/20</td>
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<tr>
<td>Collaborate With Payload Housing Manufacturer</td>
<td>Matthew</td>
<td>100%</td>
<td>12/7/19</td>
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### Spring Semester: STR Schedule

#### TASKS

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<thead>
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<th>END</th>
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<tr>
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<td>1/17/20</td>
</tr>
<tr>
<td>Theory and Concepts</td>
<td>Kevin/Michael</td>
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<td>1/13/20</td>
<td>1/17/20</td>
</tr>
<tr>
<td>Mission Requirements</td>
<td>Matthew</td>
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<td>1/13/20</td>
<td>1/17/20</td>
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<tr>
<td>Expected Results</td>
<td>Michael</td>
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<td>1/13/20</td>
<td>1/17/20</td>
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<tr>
<td>Concept of Operations</td>
<td>Logan</td>
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<td>1/17/20</td>
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<td>STR - Section 2: Final Design Description</td>
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<td>1/17/20</td>
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<tr>
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<td>1/17/20</td>
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<td>1/13/20</td>
<td>1/17/20</td>
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<tr>
<td>De-Scopes/Off-Ramps</td>
<td>Michael</td>
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<td>1/13/20</td>
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### Milestones/Presentations

- Manufacturing
- Payment Due
- Testing
- Deliverables
- Milestones/Presentations
**Spring Semester: STR Schedule**

### STR - Section 3: Hardware Procurement Update

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<tr>
<th>Design Elements</th>
<th>Team Member</th>
<th>Progress</th>
<th>Start Date</th>
<th>End Date</th>
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<tr>
<td>Electrical Design Elements: Power</td>
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<td>1/24/20</td>
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<td>Electrical Design Elements: Scintillator/SiPM</td>
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<td>1/24/20</td>
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<tr>
<td>Software Design Elements: Flight Software</td>
<td>Michael</td>
<td>0%</td>
<td>1/17/20</td>
<td>1/24/20</td>
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<tr>
<td>Mechanical Design Elements: Payload Structure</td>
<td>Matthew</td>
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<td>1/24/20</td>
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### STR - Section 4: Subsystem Testing Results

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<th>Team Member</th>
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<td>Electrical Design Elements: Power</td>
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<td>Electrical Design Elements: Geiger Counter</td>
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<td>Software Design Elements: Flight Software</td>
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<td>1/24/20</td>
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<td>Mechanical Design Elements: Payload Structure</td>
<td>Matthew</td>
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<td>1/24/20</td>
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<td>Solder Electrical Components/Test Components</td>
<td>Kevin/Logan</td>
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<td>Send Final CAD Drawings in for Manufacturing</td>
<td>Matthew</td>
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### Spring Semester: STR Schedule

#### STR - Section 5: Integrated Subsystem Testing Plan

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#### STR - Section 6: User Guide Compliance

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**Manufacturing**

**Payment Due**

**Testing**

**Deliverables**

**Milestones/Presentations**
Spring Semester: STR Schedule
### Spring Semester: ISTR Schedule

**Project Start:** Fri, 2/14/2020

**Display Week:** 1

<table>
<thead>
<tr>
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<th>ASSIGNED TO</th>
<th>PROGRESS</th>
<th>START</th>
<th>END</th>
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<td>2/21/20</td>
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<tr>
<td>De-Scopes/Off-Ramps</td>
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<table>
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## ISTR - Section 4: Integrated Subsystem Testing Status

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Integrate Electrical Components into Housing/Test Components: Kevin/Michael/Logan 0% 2/14/20 2/28/20
### Spring Semester: ISTR Schedule

#### ISTR - Section 5: Plan for Full System Integration

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## Spring Semester: ISTR Schedule

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### Integrated Testing Subsystem Review

- All Team Members
  - Start Date: 3/27/20
  - End Date: 3/27/20
### Spring Semester: FMSR Schedule

**Project Start:** Fri, 3/27/2020

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#### Milestones/Presentations

- Manufacturing
- Payment Due
- Testing
- Deliverables
- Milestones/Presentations
### Spring Semester: FMSR Schedule

#### FMSR - Section 3: Full Mission Simulation Results

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#### Full Mission Simulation Review

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## LRR - Section 1: Mission Overview

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## LRR - Section 2: Final Payload Design

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**Display Week:**
- Apr 27, 2020
- May 4, 2020
- May 11, 2020
- May 18, 2020
- May 25, 2020
- Jun 1, 2020
- Jun 8, 2020
- Jun 15, 2020

**Project Start:** Fri, 5/1/2020

**Display Week:** Apr 27, 2020 - Jun 15, 2020

**Workshop Dates:**
- May 4, 2020
- May 11, 2020
- May 18, 2020
- May 25, 2020
- Jun 1, 2020
- Jun 8, 2020
- Jun 15, 2020
## Spring Semester: LRR Schedule

### LRR - Section 3: Testing Results (Integrated/Full Mission Simulation)

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### LRR - Section 4: Launch Readiness

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## Spring Semester: LRR Schedule

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Total (No Contingency): $898.56
Total (25% Contingency): $1,222.45
# Geiger Counter Component List

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<th>Supplier</th>
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<td>555 Timer</td>
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<td>IC OSC SINGLE TIMER 8-DIP</td>
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Total (No Contingency): $132.68
Total (25% Contingency): $165.33
## Mechanical Parts List

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<td>Trays</td>
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**Total (No Contingency):** $155.36  
**Total (25% Contingency):** $185.88
# Contact Matrix

<table>
<thead>
<tr>
<th>Team Member</th>
<th>Role/Position</th>
<th>Email Address</th>
<th>Phone Number</th>
<th>US Person? (Y/N)</th>
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</thead>
<tbody>
<tr>
<td>Kevin Romero</td>
<td>Team Lead / EE</td>
<td><a href="mailto:msu-kromero8@mcneese.edu">msu-kromero8@mcneese.edu</a></td>
<td>337-499-0356</td>
<td>Y</td>
</tr>
<tr>
<td>Michael Casteel</td>
<td>Co-Lead / CE / CS</td>
<td><a href="mailto:msu-mcasteel2@mcneese.edu">msu-mcasteel2@mcneese.edu</a></td>
<td>337-287-6996</td>
<td>Y</td>
</tr>
<tr>
<td>Matthew Williams</td>
<td>ME</td>
<td><a href="mailto:msu-mwilliams23@mcneese.edu">msu-mwilliams23@mcneese.edu</a></td>
<td>337-936-9459</td>
<td>Y</td>
</tr>
<tr>
<td>Logan Gilmore</td>
<td>EE</td>
<td><a href="mailto:msu-lgilmore1@student.mcneese.edu">msu-lgilmore1@student.mcneese.edu</a></td>
<td>337-564-1648</td>
<td>Y</td>
</tr>
<tr>
<td>Faculty/Mentor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr. Li Zhuang</td>
<td>ME</td>
<td><a href="mailto:zli@mcneese.edu">zli@mcneese.edu</a></td>
<td>337-524-3663</td>
<td>Y</td>
</tr>
<tr>
<td>Dr. Stinnett</td>
<td>Physicist</td>
<td><a href="mailto:stinett@mcneese.edu">stinett@mcneese.edu</a></td>
<td>337-309-6375</td>
<td>Y</td>
</tr>
<tr>
<td>Dr. Bei Xie</td>
<td>CE</td>
<td><a href="mailto:bxie@mcneese.edu">bxie@mcneese.edu</a></td>
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</table>

**Collaboration via Microsoft Teams.**

All team members and faculty will have access to all project docs.
# Team Availability Matrix

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<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
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McNeese State University: Team Temet Nosce
Spring 2020 RS-C Team Availability Matrix
Summary of Progress

• All items have been procured.
• All electrical components have been soldered onto their respective PCBs.
• All individual electrical subsystems have been fully tested with great success.
• All electrical subsystems have been installed into/onto the payload housing and tested successfully.
• Many 30 minute test runs have been conducted.
• Expected count rates are now observed.
• Software functions as expected
• Team Temet Nosce is ahead of schedule.
Conclusion

• **Team Temet Nosce** will design/construct/implement a multi-method Cosmic Ray Detector that will soar to an apogee of approximately 120km on a WFF sounding rocket in the summer of 2020.

• **Plan for where you will take your design from here?**
  - Continued calibration of SiPM as needed.
  - Obtain polynomial that relates output of SiPM sensor to MCU input.
  - Work on data analysis software.

• **Issues, concerns, any questions?**