RockSat-X at Virginia Tech
Integrated Subsystem Testing Review (ISTR)

Kris Stone
Brennan Rausch    Nicholas Jones
03/26/2020
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
1.0 Mission Concept and Interfaces

Kris Stone
Mission Overview

• Develop a CubeSat form factor deployable solar array to enhance power generation capabilities on future university CubeSats projects

• Prove the viability of deployer design

• Future CubeSat missions will be able to take advantage of enhanced power generation
  – Compensate for surface area lost to instrumentation
  – Enable use of power-demanding electronics

• Testing our design on a Sounding Rocket will allow us to verify the design in microgravity and the space environment without the larger cost of a demonstration CubeSat mission
Success Criteria

• Minimum Success Criteria:
  1. Deployment mechanism can interface with a 1U CubeSat form factor
  2. Confirm solar array deployment after skirt separation
  3. Confirmation of power generation through measuring current and voltage across array

• Comprehensive Success Criteria:
  1. Telemeter all required sensor data to NASA Wallops Ground Station
  2. Characterize solar array performance
    • Expected vs actual power generation
  3. Successfully retract solar panel array

• Bonus: Collect acceleration and vibration data during flight
ConOps

**Altitude**

- **t = 115 sec**
  - Altitude: 113 km
  - *Video Feed and Deployment Data Collection Begins, Burn Wire Circuit Activates*

- **t = 125 sec**
  - Altitude: 125 km
  - *Solar Array Deployment*

- **t = 155 sec**
  - Altitude: 135 km
  - *Solar Array Fully Deployed*

- **t = 175 sec**
  - Altitude: 110 km
  - *Begin Solar Array Retraction*

- **t = 200 sec**
  - Altitude: 150 km
  - *Apogee*
  - **t = 197 sec**
    - Altitude: 150 km
    - *End Solar Array Retraction, Begin Power Off*

- **t = 250 sec**
  - Altitude: 87 km
  - *Skirt Separation*

- **t = 29 sec**
  - Altitude: 17.2 km
  - *End of Malemute Burn*
  - **t = 29.7 sec**
    - Altitude: 17.2 km
    - *Chute Deploys*

- **t = -2 min**
  - **-Turn on microcontrollers**
  - **-Begin collecting temperature and acceleration data**

- **t = 335 sec**
  - Altitude: 60 km
  - *Experiment Power Off*

- **t = 350 sec**
  - Altitude: 91.4 km
  - *End Solar Array Retraction, Begin Power Off*

- **t = 480 sec**
  - *Chute Deploys*

- **t = 900 sec**
  - *Splash Down*
Payload Location

Aft

- UPR
- Exp5Sys1
- Exp5Sys2
- Exp4Sys1
- Exp3
- Exp2
- Exp1Sys2
- Exp1Sys1

Forward
Solar Panels deploying in the Nadir direction.
90 deg incidence angle to the Sun.
## Timer Event Matrix

<table>
<thead>
<tr>
<th>Event</th>
<th>Time On</th>
<th>Dwell</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSE 1</td>
<td></td>
<td></td>
<td>University of Puerto Rico</td>
</tr>
<tr>
<td>GSE 2</td>
<td>T-120 sec</td>
<td>Flight</td>
<td>Power flight controller and begin collecting acceleration and temperature data</td>
</tr>
<tr>
<td>TE-1</td>
<td></td>
<td></td>
<td>University of Puerto Rico</td>
</tr>
<tr>
<td>TE-2</td>
<td></td>
<td></td>
<td>University of Puerto Rico</td>
</tr>
<tr>
<td>TE-3</td>
<td></td>
<td></td>
<td>University of Puerto Rico</td>
</tr>
<tr>
<td>TE-R</td>
<td>T+115 sec</td>
<td>160 sec</td>
<td>Signal deployment and retraction sequence initiation</td>
</tr>
</tbody>
</table>
# Pin Assignments: Power

## Power Connector--Customer Side

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>TE-RA (deployment / retraction timer)</td>
</tr>
<tr>
<td>3</td>
<td>TE-RB (deployment / retraction timer)</td>
</tr>
<tr>
<td>4</td>
<td>N/A</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
</tr>
<tr>
<td>6</td>
<td>GND</td>
</tr>
<tr>
<td>7</td>
<td>GND</td>
</tr>
<tr>
<td>8</td>
<td>N/A</td>
</tr>
<tr>
<td>9</td>
<td>GSE_2 (28V main power bus)</td>
</tr>
<tr>
<td>10</td>
<td>N/A</td>
</tr>
<tr>
<td>11</td>
<td>N/A</td>
</tr>
<tr>
<td>12</td>
<td>N/A</td>
</tr>
<tr>
<td>13</td>
<td>N/A</td>
</tr>
<tr>
<td>14</td>
<td>N/A</td>
</tr>
<tr>
<td>15</td>
<td>N/A</td>
</tr>
</tbody>
</table>
## Pin Assignments: Telemetry

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
<th>Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Analog 1 (Solar Array Current)</td>
<td>20</td>
<td>Bit - 7</td>
</tr>
<tr>
<td>2</td>
<td>Analog 2 (Solar Array Voltage)</td>
<td>21</td>
<td>Bit - 8</td>
</tr>
<tr>
<td>3</td>
<td>Analog 3 (Deployment Data)</td>
<td>22</td>
<td>Bit - 9</td>
</tr>
<tr>
<td>4</td>
<td>Analog 4 (Payload Temp)</td>
<td>23</td>
<td>Bit - 10</td>
</tr>
<tr>
<td>5</td>
<td>N/A</td>
<td>24</td>
<td>Bit - 11</td>
</tr>
<tr>
<td>6</td>
<td>N/A</td>
<td>25</td>
<td>Bit - 12</td>
</tr>
<tr>
<td>7</td>
<td>N/A</td>
<td>26</td>
<td>Bit - 13</td>
</tr>
<tr>
<td>8</td>
<td>N/A</td>
<td>27</td>
<td>Bit - 14</td>
</tr>
<tr>
<td>9</td>
<td>N/A</td>
<td>28</td>
<td>Bit - 15</td>
</tr>
<tr>
<td>10</td>
<td>N/A</td>
<td>29</td>
<td>Bit - 16</td>
</tr>
<tr>
<td>11</td>
<td>Bit - 1</td>
<td>30</td>
<td>Parallel Strobe</td>
</tr>
<tr>
<td>12</td>
<td>Bit - 2</td>
<td>31</td>
<td>N/C</td>
</tr>
<tr>
<td>13</td>
<td>Bit - 3</td>
<td>32</td>
<td>N/A</td>
</tr>
<tr>
<td>14</td>
<td>Bit - 4</td>
<td>33</td>
<td>N/A</td>
</tr>
<tr>
<td>15</td>
<td>Bit - 5</td>
<td>34</td>
<td>N/C</td>
</tr>
<tr>
<td>16</td>
<td>Bit - 6</td>
<td>35</td>
<td>N/C</td>
</tr>
<tr>
<td>17</td>
<td>N/C</td>
<td>36</td>
<td>GND</td>
</tr>
<tr>
<td>18</td>
<td>GND</td>
<td>37</td>
<td>GND</td>
</tr>
<tr>
<td>19</td>
<td>GND</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Updated Power Budget

## Virginia Tech RockSat-X - Power Budget

<table>
<thead>
<tr>
<th>Date</th>
<th>Wallops Power Line</th>
<th>Subsystem</th>
<th>Voltage (V)</th>
<th>Max Current (A)</th>
<th>Start Time (min)</th>
<th>Time On (min)</th>
<th>Watts</th>
<th>Ah</th>
</tr>
</thead>
<tbody>
<tr>
<td>02/12/20</td>
<td><strong>GSE 2</strong></td>
<td>Microcontrollers</td>
<td>5.0</td>
<td>2.50</td>
<td>T-2</td>
<td>7.58</td>
<td>12.50</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Environment Sensors</td>
<td>5.0</td>
<td>0.04</td>
<td>T-2</td>
<td>7.58</td>
<td>0.18</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Experiment Sensors</td>
<td>5.0</td>
<td>0.42</td>
<td>T+1.83</td>
<td>2.83</td>
<td>2.10</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Burn Wire System</td>
<td>5.0</td>
<td>2.00</td>
<td>T+1.92</td>
<td>0.1</td>
<td>10.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Motor Control</td>
<td>9.0</td>
<td>2.00</td>
<td>T+2.08, T+4.58</td>
<td>1</td>
<td>18.00</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td><strong>TER</strong></td>
<td>Timer Event Handler</td>
<td>28.0</td>
<td>0.01</td>
<td>T+1.92</td>
<td>2.67</td>
<td>0.20</td>
<td>0.00</td>
</tr>
</tbody>
</table>

## Total Power Budget Summary

<table>
<thead>
<tr>
<th></th>
<th>Watts</th>
<th>Ah</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSE 2 Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TE R Total</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>6.96</td>
<td>0.38</td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Power Capacity</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>Over/Under</td>
<td>0.12</td>
<td></td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td># of Flights Margin</td>
<td>2.7</td>
<td></td>
</tr>
</tbody>
</table>
## Detailed Weight Budget

- Based on the final mass of the payload, ballast blocks machined of steel will be used to correct center of mass while additionally bringing the total mass up to the required 15 pound threshold.
- Final ballast mass will be established based on final disposition of payload.
- Multiple blocks may be used as to not interfere with mission-critical functions.

### Mass Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Total Mass (lbf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payload Deck</td>
<td>3.425</td>
</tr>
<tr>
<td>Electrical Housing</td>
<td>2.051</td>
</tr>
<tr>
<td>Motor</td>
<td>1.03</td>
</tr>
<tr>
<td>Solar Array</td>
<td>1.63</td>
</tr>
<tr>
<td>Camera</td>
<td>0.33</td>
</tr>
<tr>
<td>3 Screw Switches</td>
<td>~0.022</td>
</tr>
<tr>
<td>Range finder</td>
<td>0.0101</td>
</tr>
<tr>
<td>Wiring, Mounts, Tie-downs, and</td>
<td></td>
</tr>
<tr>
<td>Ballast</td>
<td>6.5019</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15</strong></td>
</tr>
<tr>
<td><strong>Over/Under</strong></td>
<td><strong>(0.00)</strong></td>
</tr>
</tbody>
</table>
2.0 Design Overview

Nicholas Jones          Brennan Rausch
System Changes Since STR

• Actions assigned during STR:
  – Deploying west should not interfere with another payload
  – Burn wire on the protoboard
  – Deployment issues: adding joints to both sides

• What major changes since STR:
  – Scissor joints were added to both sides of the solar array deployer to create a stronger structure. This will not change mission objectives.
  – Springs have been added to help facilitate retraction and make sure the array is within the keep-out zone during re-entry.
  – Changed to all hardware interrupts
Design Overview: Individual Components
Design Overview: Top View
Design Overview: CoM Projection

Y: 1.93 in
Z: 0.13 in
X: 0.14 in
Design Overview: Retracted Side View

Scissor Joints on both sides
Functional Block Diagram
Hazardous Mechanical Items

- Identify all materials that may be considered hazardous
  - none
- Mechanical operations that may be considered hazardous
  - Solar array deployment
- Identify all mechanical components that may be hazardous or interfere with other payloads or rocket systems
  - Solar Array Deployer changes CoM
Hazardous Electrical Items

• No high voltage being used
• Operational hazards
  – Charging battery on-board
    • Charging can be disabled through hardware interrupt
  – Burn wire circuit
    • Firing can be disabled through hardware interrupt
Special Requests

- The only special request that we have is our pointing request specification. Due to having a solar experiment, the best incident angle to the sun during our time at apogee would be optimal.
3.0 Subsystem Testing Status
Mechanical Subsystem Testing Status

• Solar Panel Deployer (70%)
  ○ Need to be tested: test with aluminum and carbon fiber
  ○ Need to be tested: Endplate Level Testing

• Actuation Motor (95%)
  ○ Testing of the motor system itself is complete, only software changes to be made to ensure 1”/s deployment when integrated

• Burn Wire Resistor Network (90%)
  ○ The burn-time is sufficient and the transistor and protoboard tested soon

• Electrical Housing - Arduino Mega, Raspberry Pi, main PCB, Battery (100%)
  ○ Testing on heat analysis of internal components do not exceed their operating limit
Electrical Subsystem Testing Status

- Solar Panel PCBs (100%)
- Sensors (95%)
  - Close out basic sensor testing
- Command and Control Hardware (90%)
  - Implement and test timer event handling
- Power (65%)
  - Complete timer event handling testing and close out debugging of power supply circuit
- Telemetry (100%)
- PCB (0%)
  - Revisions to PCB design such as addition of now 16-bit telemetry lines, signal conditioning circuitry, and possible adherence to Puerto Rico power management scheme have delayed ordering the physical boards
Subsystem Testing Status

Solar Array Deployer

Deployment with gravity off-loading, Deployment at multiple angles and retraction with a spring system with joints on both sides are fully completed. Endplate alignment is partially completed.

Tests with aluminum and carbon fiber have not been tested but will be by FMSR.

Task 1: Take pictures of the scissor joints before and after deployment and observe the angle of deployment.
- Scissor Joints both sides:
  - Does not retract completely
  - Expands and retracts smoothly using the endplate to pull/push
  - Can deploy with an angle at the full expansion for mission, about ~20 degrees from flat

Task 2: Test at five different angles: all success
- Scissor Joints both sides: Straight up (with gravity off-loading), Straight down, Parallel to the floor, 45 up off the floor, and 45 down off the floor
Subsystem Testing Status

Solar Array Deployer

Tests with aluminum and carbon fiber have not been tested but will be by FMSR.
- Working on manufacturing components for flight model
- Incremental design tweaking would be delicate in light of operations restrictions placed by the university and government
- Manufacturing will take 6 weeks from shipping materials
  - Have located shop willing to complete work
Subsystem Testing Status

Burn Wire Resistor Network

The Burn Wire Mechanism have been tested with great success

The burn time is satisfactory

The transistor and protoboard have not been tested but will be by March 29, 2020
Subsystem Testing Status

Electrical Housing Heat Analysis:

Heat Sources: Solar Radiation and Dissipated Heat

Conduction Heat from atmosphere was ignored due to the altitude

<table>
<thead>
<tr>
<th>Equipments</th>
<th>Operational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arduino Mega</td>
<td>-40 to 85 C</td>
</tr>
<tr>
<td>Rasp Pi B3+</td>
<td>0 to 50 C</td>
</tr>
<tr>
<td>Battery</td>
<td>0 to 45 C</td>
</tr>
<tr>
<td>PCBs</td>
<td>-10 to 110 C</td>
</tr>
</tbody>
</table>

Q-solar = S*A*a, where S is the solar constant A is the exposed area and a is absorptivity

Q-dissipated = P*t, where P is the power usage and t is the duration time

Q = m*c*(T2-T1), where m is mass, c is specific heat, and T represents the temperature

<table>
<thead>
<tr>
<th>Amb. Temp Rise</th>
<th>12.63406527</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Rise</td>
<td>40.4441493</td>
</tr>
</tbody>
</table>
Cell characterization, PCB checkout and validation were both successfully conducted. Every panel has undergone thermal vacuum testing and successfully passed. Subsystem is ready to be integrated with other systems.
Sensors Testing Status

LM20 Temperature

- The LM20 has been successfully tested on breadboard.
- The sensor is accurate up to 2.16%.

INA 219

- Successfully breadboarded
- Read voltages and current using sample resistor circuits
- Needs to be tested with use-case respective values

ADXL 377

- Successfully breadboarded
- Reads gravitational acceleration on all axis
- Successfully conducted “rough” high acceleration tests

TTL Serial Camera

- Successfully run on flight computer hardware
- Need to complete blinding test
Sensors Testing Status

Rangefinder Testing

Rangefinder accuracy has been characterized
Blinding test and static test with deployer have been successfully conducted

Need to conduct further testing using actual end plate material
Incidence Angle Detection

Full demonstration of incidence angle detection using OpenCV has been conducted, with the RaspPi performing computations.
Control Software Testing Status

Control Software

- Full demonstration of control loop running with all sensors (Incidence angle detection, temp sensors, range finder, TTL Serial camera)

- Timer event handling has yet to be tested, but consists of basic interrupt handling, making us confident this will not be an issue.
Subsystem Testing Status

Analog Telemetry Subsystem

- Prototyped and tested the low pass filter to convert PWM to Analog.
  - testing verified the component values in the filter
  - the filter performs as expected
Subsystem Testing Status

Power Distribution System

5v rail is having voltage spikes - drastically exaggerated by oscilloscope wires. Remedy is likely using lab-grade probes + filter cap.
9v rail works flawlessly.
Was able to successfully boot up Pi + Arduino sensor suite
Subsystem Testing Status

Timer Event Handling

Timer event handling system has been tested with a multimeter successfully - however it has not been integrated with a microcontroller to get actual readings.
Subsystem Testing Status

Printed Circuit Board (PCB)  0%

- PCB consists of (4) boards all designs are in final state
  - Main Deck Plate, handling all sensor data and power management
  - Daughter Board, acting as a passthrough for sensor data to Arduino and RaspPi
  - Sensor End-Panel, used for solar array temp monitoring and solar incidence angle detection
  - Burn-Wire Circuitry, handling burn-wire operation external to electronics enclosure
- Team review is pending for this coming week to send boards off to be manufactured
Subsystem Testing Status

Printed Circuit Board (PCB)

Main Board

Daughter Board

Burn-Wire Board

Sensor End-Panel
4.0 Integrated Subsystem Testing Status
Integrated Subsystem Testing Status

- Subsystems that have been or will be integrated and tested:
  - Solar Array Deployer and Range Finder
    - Purpose: Confirm deployment length.
    - Results: Will run a similar test as discussed to see if our results are the same.
  - Solar Array Deployer and Actuation Motor
    - Purpose: Confirm 1” deployment and similar movement of the array compared to manual testing
    - Results: We will analyze the video to confirm the speed of deployment.
  - Solar Array Deployer and Solar Cells
    - Purpose: Confirm the solar cells fit properly, the deployer can retract properly, and wires are routed correctly
    - Results: Successful fit and retraction; the wires have not been routed
  - Solar Array Deployer and Burn Wire Resistor Network
    - Purpose: Confirm burn-wire time and that the structure is secure during launch
    - Results: Additional testing needs to be done with the wire in greater tension
  - Electrical Housing - Arduino Mega, Raspberry Pi, main PCB, Battery, and external Camera
    - Purpose: Each component in the electrical housing will be stacked on top of each other. Components will be fixed in their positions through the use of screws that will be inserted on the inside edges of the electrical housing. The screws will act as a mount for each of the components.
    - Results: Stabilize components operate after vibration testing.
  - Solar Array Deployer and Endplate Components - Not Started
    - Purpose: Confirm the PCB with the temperature sensor and incidence angle camera fit properly, the camera is angled correctly, and the wires are routed correctly
    - Testing will be completed once the PCB is received
1.0 Solar Array Deployer and Range Finder

We will confirm an accurate measurement of the deployment. Test was completed on March 6th with some success. A slight angle of the endplate causing significant change in the distance reading. Further testing will be done in two weeks with the real endplate material.
Integrated Subsystem Testing Status:

2.0 Solar Array Deployer and Actuation Motor

This will confirm 1"/s deployment and similar movement of the solar array compared to manual testing.

Tests with aluminum and carbon fiber have not been tested but will be by FMSR.

Top View of Actuation Motor
Integrated Subsystem Testing Status

3.0 Solar Array Deployer and Solar Cells

This confirm the solar cells fit properly, the deployer can retract properly. We will need to route the wires by this next week to confirm the array does not interfere. Test was completed on March 6th with great success.
Integrated Subsystem Testing Status:

4.0 Burn Wire Resistor Network and Solar Array Deployer

This will verify that the burn time stays within the expected range and that the structure is locked safely.

Test was completed on March 2 with great success. Additional tests will be conducted the week of March 29. This includes testing the circuit with a transistor on protoboards.
Integrated Subsystem Testing Status:

5.0 Electrical Housing - Arduino Mega, Raspberry Pi, main PCB, Battery, and external Camera

- The electrical housing will be placed on its side and will be stabilized using L brackets.
- The components within the housing will be stabilized by stacking the PCB, Raspberry Pi, and Arduino by attaching the stack to the holes located within the electrical housing
  - Each component within the electrical housing has mounting holes which will be used to attach them to the housing.
Integrated Subsystem Testing Status:

L bracket attached on this face

These holes will be used to mount the stack of components within the housing
Integrated Subsystem Testing Status:

- L Brackets position on the bottom face of the electrical housing.
- The camera will be mounted on the L bracket.
Flight Computer Testing Status

Sensors

- Temperature Sensor
- Accelerometer
- Range Finder
- TTL Serial Camera
- Current/Voltage Sensor

All tested for functionality, tested for accuracy, tested as one whole block, and added to and tested with the control software.

Flight computer PCBs will need to be tested for functionality one assembled.
Integrated Subsystem Testing Status:

Control Software and Power Delivery System

This testing will ensure that the power delivery system and flight computer hardware can operate cohesively. This testing will include ensuring timer event handling is correct.

Testing has been completed with initially successful results. Additional tests will be conducted next week to ensure updated design for power delivery system is sufficient for system power.
Integrated Subsystem Testing Status

Telemetry and Ground Station

- Converting images and sensor data to bitstream and all associated functions have been tested and work as expected.
- Reading and responding to the parallel strobe with 8 bits has been tested and is working as expected.
- A full file transfer from the flight computer to the simulated ground station has not yet been tested but will be by April 3rd.
- 16 bit parallel transmission has not yet been tested but will be by April 7th.
Integrated Subsystem Testing Status

Solar Charging & Solar Panels

An attempt to use the Solar Charging System directly with the manufactured solar panels has been made, however, not enough panels were connected to have sufficient voltage to charge the battery.
5.0 Plan for Full Mission Simulation Review (FMSR)

Nicholas Jones

Brennan Rausch
Mechanical Testing and Integration

○ Future subsystem testing for overall mechanical design
  ■ Test the solar array deployment mechanism with full mission materials (aluminum and carbon fiber)

○ Future integrated subsystem testing for overall mechanical design
  ■ Solar Array Deployer and Range Finder will need to further test the distance reading to the endplate.
  ■ Solar Array Deployer and Actuation Motor will need to run at 1”/s deployment speed.
  ■ Solar Array Deployer and Solar Cells will need to route wires to the cells.
  ■ Solar Array Deployer and Endplate Components will need to route wires and take camera and temperature data.

• **Mechanical Inhibits**
  ○ We will be using screw switches for the burn wires and deployment mechanism. A screw will complete the circuit to allow these components to operate.
Mechanical Testing and Integration

### Timeframe

<table>
<thead>
<tr>
<th>April 2020</th>
<th>May 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/30</td>
<td>Subsystem: Endplate Leveling Test</td>
</tr>
<tr>
<td>4/1</td>
<td>Integrated Subsystem: Solar Array Deployer and Solar Cells</td>
</tr>
<tr>
<td>3/30</td>
<td>4/3</td>
</tr>
<tr>
<td></td>
<td>Integrated Subsystem: Solar Array Deployer and Actuation Motor</td>
</tr>
<tr>
<td>4/6</td>
<td>4/10</td>
</tr>
<tr>
<td></td>
<td>Integrated Subsystem: Solar Array Deployer and Range Finder</td>
</tr>
<tr>
<td>4/6</td>
<td>4/10</td>
</tr>
<tr>
<td></td>
<td>4/13</td>
</tr>
<tr>
<td></td>
<td>Integrated Subsystem: Solar Array Deployer and Endplate Components</td>
</tr>
<tr>
<td></td>
<td>4/30</td>
</tr>
</tbody>
</table>

### Timeline

<table>
<thead>
<tr>
<th>Start Apr 5, 2020</th>
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<tbody>
<tr>
<td>Subsystem: Mon 3/30/20 - Fri 4/3/20</td>
</tr>
<tr>
<td>Integrated Subsystem: Mon 3/30/20 - Fri 4/3/20</td>
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</table>

<table>
<thead>
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<th>Apr 12, 2020</th>
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<tr>
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<td>Integrated Subsystem: Mon 4/6/20 - Fri 4/10/20</td>
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</table>

<table>
<thead>
<tr>
<th>Apr 19, 2020</th>
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</thead>
<tbody>
<tr>
<td>Integrated Subsystem: Solar Array Deployer and Endplate Components Mon 4/13/20 - Thu 4/30/20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Apr 26, 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finish Thu 4/30/20</td>
</tr>
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### Electrical and Software Testing and Integration

<table>
<thead>
<tr>
<th>Action Item</th>
<th>Target Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Close out of sensor testing</td>
<td>March 30th - April 3rd</td>
</tr>
<tr>
<td>Solar Panel Array Integration</td>
<td>March 30th - April 3rd</td>
</tr>
<tr>
<td>Integration of solar panel and battery systems</td>
<td>March 30th - April 3rd</td>
</tr>
<tr>
<td>Telemetry Integration</td>
<td>April 6th - April 10th</td>
</tr>
<tr>
<td>Flight Computer Integration with PCBs and Inhibits, Completion of Flight Software</td>
<td>April 13th - 17th</td>
</tr>
<tr>
<td>Ground Station Integration, Completion of Ground Station Software</td>
<td>April 13th - 17th</td>
</tr>
<tr>
<td>Integrate Completed Flight Computer and Electronics Package with payload</td>
<td>April 20th - April 24th</td>
</tr>
<tr>
<td>Full Mission Simulations</td>
<td>April 20th - April 24th</td>
</tr>
</tbody>
</table>

- **Battery charging will be inhibited with a hardware interrupt**
System Level Testing

- System level testing will rely on use of ground station simulator currently being produced
  - Will verify systems in order of dependency
    - Telemetry & Power
    - Command and Control Hardware
    - Sensors
    - Deployment Control and Actuation
      - Actuation of deployer hardware
      - Verify integrity and repeatability
    - Solar Panel and Battery Performance
  - Potential to do vibrations testing with NGIS before June Operations
Plan for FMSR

• Completion of FMSR goals will rely on creating up-to-date and detailed testing and manufacturing plans from members no longer in the area
  ○ Team members in the area will execute these plans as possible
  ○ Focus on task tracking and communication through Trello boards and regular online meetings
  ○ Focus on reducing risk and complexity where possible

• Major Hurdles
  ○ Classes will be out until March 23rd
  ○ Classes will be online for the rest of the semester
  ○ All On-Campus machine shops are closed for now, forcing us to look at commercial options
  ○ Lab space has restricted access for undergraduate students
    ■ One member still has access
6.0 Project Schedule

Kris Stone
Schedule

- Integrated Subsystem Testing Review (ISTR) 100%
- Integrate Key Systems

- Full Mission Simulation Review (FMSR) 25%

- Conduct Mission Simulation and Testing/Integrated Subsystem testing

- Integration Readiness Review (IRR) 0%

- Launch Readiness Review Packages (LRR)
June Operations

- **RS-X GSE**
  - Will use replaceable burn wire circuits to enable testing and demonstration

- **Sequence testing with Wallops GSE**
  - Can enable or disable hazardous features as requested

- **Wallops RFI testing**
  - Not using RF
  - Can enable or disable hazardous features as requested

- **Vibration testing**
  - Can disable hazardous features

- **Post-vibe sequence testing with Wallops GSE**
  - Can enable or disable hazardous features as requested
Payload Special Operations/Inhibits

**Electrical**

- The following actions will have built-in electrical inhibits to conform to test requirements and enable safe testing of the payload
  - Battery Charging - inhibit will create an open circuit to disable charging
  - Motor Deployment - inhibit will create an open circuit to prevent deployment
  - Burn wire Circuit Activation - inhibit will create an open circuit to prevent activation

- Will be using screw switches
  - When the screw are absent, operation will be disabled.
June Operations

• Describe all aspects of your payload that will not be present or available for testing in June
  ○ We do not anticipate any subsystems NOT being ready for June testing
June Operations

• Describe what features of your payload cannot and/or will not be tested on the ground and the reasons why
  ○ Due to NASA Wallops regulations, charging and discharging of the Li-Ion battery will not be able to be simulated during electrical HITL tests
    ■ Hardware inhibits are in place to separate this feature from the full-mission simulation.
    ■ A voltage / current measurement can be recorded at the electrical inhibit interface to ensure proper functionality
7.0 Project Management

Kris Stone
## User Guide Compliance

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Status/Reason (if needed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center of gravity in 1&quot; plane of plate?</td>
<td>YES</td>
</tr>
<tr>
<td>Weight 30.0+/− 1.0 (15.0+/− 0.5) lbs?</td>
<td>YES</td>
</tr>
<tr>
<td>Max Height &lt; 10.75&quot; (5.13&quot;)</td>
<td>YES</td>
</tr>
<tr>
<td>Bottom of deck has flush mount hardware?</td>
<td>YES, see picture on slide 48</td>
</tr>
<tr>
<td>Within Keep-Out Zone</td>
<td>YES, see picture on slide 56</td>
</tr>
<tr>
<td>Using &lt; 10 A/D Lines</td>
<td>YES, Using 4 lines</td>
</tr>
<tr>
<td>Using/Understand Parallel Line</td>
<td>YES, Using bits 1-16</td>
</tr>
<tr>
<td>Using/Understand Asynchronous Line</td>
<td>NOT USING</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>NOT USING</td>
</tr>
<tr>
<td>Using X Redundant Power Lines (TE-R)</td>
<td>YES</td>
</tr>
<tr>
<td>Using &lt; 1 Ah (&lt; 0.5 Ah for half payload)</td>
<td>YES</td>
</tr>
<tr>
<td>Using &lt;= 28 V</td>
<td>YES</td>
</tr>
<tr>
<td>Using RF (If yes, list frequency and TX Power)</td>
<td>NO</td>
</tr>
<tr>
<td>Using deployable?</td>
<td>YES, but speed is under 1 inch per second</td>
</tr>
<tr>
<td>Whole team consists of US Persons</td>
<td>NO, 3 Non-US Persons (Will comply with restrictions)</td>
</tr>
<tr>
<td>Using ITAR and/or Export Controlled hardware</td>
<td>NO</td>
</tr>
</tbody>
</table>
Update on Partnerships

- **Virginia Space Grant Consortium (VSGC)**
  - Funding ($2,500) + potentially more for the Spring installment

- **VT Aerospace and Ocean Engineering Dept**
  - Funding ($5,000)
  - Dr. Kevin Shinpaugh (SME) and Principal Investigator

- **VT Student Engineering Council**
  - Funding ($2,580)
  - More funding from “Big Contribution Fund” in April

- **Space@VT**
  - Funding ($550) + ($500) for second installment in April
  - Dr. Scott Bailey (SME)

- **Northrop Grumman Innovation Systems (NGIS)**
  - Funding ($10,000)
  - Ben Heckman (SME) + Randy Spicer (SME)

- **The Boeing Company**
  - Funding (TBD, Spring 2020)
  - Dr. Robert A. Smith (SME)
Organizational Chart

Kris Stone
Team Lead

Nicholas Jones
Electrical Lead

Kathryn Robertson
Riya Sareen
Hunain Shamsi

Spencer Buebel
Danny Flynn
Jacob Di Girolamo
Christopher Mattson

Brennan Rausch
Mechanical Lead

Farieddin Bazzal
Matt Brockmeyer
Surahbi Srivastava

Stuart Scarton
Eric Williams

Team Advisor
Dr. Kevin Shinpaugh
## Budget

<table>
<thead>
<tr>
<th>Funding Granted</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kevin T Crofton AOE Department</td>
<td>$5,000</td>
</tr>
<tr>
<td>VSGC</td>
<td>$2,500</td>
</tr>
<tr>
<td>Student Engineering Council</td>
<td>$2,580</td>
</tr>
<tr>
<td>Northrop Grumman Innovation Systems</td>
<td>$10,000</td>
</tr>
<tr>
<td>Space@VT</td>
<td>$550</td>
</tr>
<tr>
<td>GoFundMe Campaign</td>
<td>$800</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$21,430</strong></td>
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## Funding Needed

<table>
<thead>
<tr>
<th></th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program</td>
<td>$14,000  ($8,000 deposited)</td>
</tr>
<tr>
<td>Parts</td>
<td>$3,584</td>
</tr>
<tr>
<td>Travel</td>
<td>$1,000</td>
</tr>
<tr>
<td>Outreach</td>
<td>$500</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$19,084</strong></td>
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</tbody>
</table>
Example Team Picture
# Latest Contact Matrix

## Virginia Tech

### Fall 2019 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 Lead</td>
<td>Kristofer Stone</td>
<td>5402927083</td>
<td>5402927083</td>
<td>Yes</td>
<td><a href="mailto:kristo7@vt.edu">kristo7@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Electrical Subteam Lead</td>
<td>Nicholas Jones</td>
<td>7577515263</td>
<td>7577515263</td>
<td>Yes</td>
<td><a href="mailto:njones31@vt.edu">njones31@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Electrical</td>
<td>Kathryn Robertson</td>
<td>4104916597</td>
<td>4104916597</td>
<td>Yes</td>
<td><a href="mailto:kathrynr@vt.edu">kathrynr@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Electrical</td>
<td>Danny Flynn</td>
<td>3015205981</td>
<td>3015205981</td>
<td>Yes</td>
<td>pdf <a href="mailto:Flynn@vt.edu">Flynn@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Electrical</td>
<td>Jacob Di Girolamo</td>
<td>5715288477</td>
<td>5715288477</td>
<td>Yes</td>
<td>jacob <a href="mailto:dig@vt.edu">dig@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Electrical</td>
<td>Hunain Shamsi</td>
<td>5409986669</td>
<td>5409986669</td>
<td>Yes</td>
<td><a href="mailto:hunainali99@vt.edu">hunainali99@vt.edu</a></td>
<td>Pakistani Citizen</td>
<td>Yes</td>
</tr>
<tr>
<td>Electrical</td>
<td>Chris Mattson</td>
<td>5408186542</td>
<td>5408186542</td>
<td>Yes</td>
<td><a href="mailto:cmattson98@vt.edu">cmattson98@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Electrical</td>
<td>Spencer Buebel</td>
<td>9192594036</td>
<td>9192594036</td>
<td>Yes</td>
<td><a href="mailto:stbuebel@vt.edu">stbuebel@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Electrical</td>
<td>Riya Sareen</td>
<td>5404498983</td>
<td>540498983</td>
<td>Yes</td>
<td><a href="mailto:riyas6@vt.edu">riyas6@vt.edu</a></td>
<td>Indian Citizen</td>
<td>Yes</td>
</tr>
<tr>
<td>Mechanical Subteam Lead</td>
<td>Brennan Rausch</td>
<td>7577590588</td>
<td>7577590588</td>
<td>Yes</td>
<td><a href="mailto:rbrenn17@vt.edu">rbrenn17@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Mechanical</td>
<td>Surabhi Srivastava</td>
<td>5405979329</td>
<td>5405979329</td>
<td>Yes</td>
<td><a href="mailto:suv98@vt.edu">suv98@vt.edu</a></td>
<td>Indian Citizen</td>
<td>Yes</td>
</tr>
<tr>
<td>Mechanical</td>
<td>Matthew Brockmeyer</td>
<td>6312557666</td>
<td>6312557666</td>
<td>Yes</td>
<td><a href="mailto:mbrock@vt.edu">mbrock@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
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<tr>
<td>Mechanical</td>
<td>Eric Williams</td>
<td>4343056441</td>
<td>4343056441</td>
<td>Yes</td>
<td><a href="mailto:ericw500@vt.edu">ericw500@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
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<tr>
<td>Mechanical</td>
<td>Farid Bazzal</td>
<td>5715980861</td>
<td>5715980861</td>
<td>Yes</td>
<td><a href="mailto:fdbazzal@vt.edu">fdbazzal@vt.edu</a></td>
<td>US Permanent Resident</td>
<td>Yes</td>
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## Availability Matrix

<table>
<thead>
<tr>
<th>Time</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
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<tbody>
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<tr>
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<td>1</td>
<td>2</td>
</tr>
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</table>
8.0 Conclusions

Kris Stone
Worries and Concerns

• Currently the COVID-19 pandemic is our biggest deterrent.
  – Having a team that is dispersed both on-campus and off is going to be challenging for prototyping and testing
  – Limited access to lab space adds an additional strain towards the team with only one member currently having access to this facility

• Plans to mitigate these issues
  – High levels of communication on both Slack and Trello task tracking
  – Supplying parts to those who can be here for testing and can complete this remotely
  – Senior members have many of the lab tools at home which may supplement losses in equipment access
Conclusion

• Have not heard back from Puerto Rico concerning the DC-DC converter discussion
• Are there any contingency plans in place for NASA Wallops concerning COVID-19 and upcoming testing dates?
  – Are there any travel restrictions currently in place?
• For the launch fee deposits, if the program is cancelled will those fees be refundable to the team?