RockSat-X @ Virginia Tech
Critical Design Review 12/20/18

Virginia Tech
Tony DeFilippis, Alex Halberg, Kris Stone, Simran Singh
CDR Presentation Outline

• Section 1: Mission Overview
• Section 2: System Overview
• Section 3: Subsystem Design
• Section 4: Prototyping/Analysis
• Section 5: Manufacturing Plan
• Section 6: Testing Plan
• Section 7: User Guide Compliance
• Section 8: Project Management Plan (PMP)
1.0 Mission Overview

Anthony DeFilippis / Simran Singh
Mission Overview: Mission Statement

• Mission Statement
  – Test a deployable solar array for future CubeSat or other small satellite energy production applications during suborbital flight

• Evaluate performance of solar array and its feasibility for future energy harvesting applications.

• Data obtained can be used for energy harvesting in future payloads

• Flying this mission on a rocket would expose it to an appropriate environment to test deployment mechanisms and evaluate the solar array performance.
Mission Overview: Mission Objectives

• Mission Objectives
  – Successfully deploy a solar array from a sounding rocket payload deck.
  – Successfully retract solar array and recover payload intact after re-entry and splashdown
  – Successfully use power generated by the solar array to run at least one onboard sensor
    • Potential incorporation of MLI, sun sensor, radiation sensor, cameras, etc.
Mission Overview: Theory and Concepts

• Mission goal is to deploy a solar array from a CubeSat form factor and characterize system performance pertaining mainly to electrical energy production.

• By deploying the array from a sounding rocket we believe we can test the solar array in a space environment more cheaply than a test involving an actual CubeSat deployed to orbit and can recover the payload for energy production analysis.

• Previous research on CubeSat solar arrays has been conducted by NASA which prepared a prototype (XSAS) which has been tested in a microgravity environment on Earth.
Mission Overview: Expected Results

• Data collection is to be done by a suite of sensors on board which will monitor the temperature of the array, record a video to monitor array deployment, measure the two axis strain imposed on the array upon deployment.

• Data analysis would be done through monitoring different deployment methods and performance comparison of sections with and without MLI material.

• An analysis on the effect of temperature on the performance solar panels will also be done as the efficiency of the energy production done by the panels is influenced by the temperature. The higher the temperature of the solar panels, the less efficient they will be in energy production.
ConOps Overview: Mission Profile

Altitude

1. Launch: $t = 0$
   - Telemetry/GPS begins

2. Skirt Separation: $t = 1.3$
   - Telemetry/GPS continues
   - Skirt Separation

3. Panel Deploy: $t = 1.7$
   - Telemetry/GPS continues
   - Data acquisition begins

4. Data Acq.: $t = 1.7-4.5$
   - Telemetry/GPS continues
   - Data acquisition continues

5. Panel Retract: $t = 4.5$
   - Telemetry/GPS continues
   - Panel Retraction
   - Data acquisition terminates

6. Landing: $t = 15$
   - Telemetry/GPS terminates
   - Payloads recovered

- All systems on
- Begin telemetry/GPS
- Initiate ground station software connections

- Panel Deployment
- Apogee
- Panel Retraction
- Continued Telemetry & Data Collection
- End of Malemute Burn
- Chute Deploys

$2019$ CoDR

$\text{Altitude: 75 km}$
$\text{Altitude: 95 km}$
$\text{Altitude: ~150 km}$
$\text{Altitude: 52 km}$

$1.3\text{ min}$
$1.7\text{ min}$
$3.1\text{ min}$
$4.0\text{ min}$
$4.5\text{ min}$
$7.5\text{ min}$
$15\text{ min}$
Event Sequence

Event 1 (t = 0 minutes): Launch (GSE-1)
- All systems on; telemetry begins; initiate software links

Event 2 (t = 1.3): Skirt Separation
- Main skirt separation; prep for deployment; telemetry continues

Event 3 (t = 1.7): Panel Deployment (TE-1)
- Solar panel/array extend; initiate data acquisition; telemetry continues

Event 4 (t = 4.0): Data Acquisition
- Data acquisition continues from Event 3 through Event 5

Event 5 (t = 4.5): Panel Retraction (Computer timed event)
- Solar panel/array retracts; data acquisition terminates

Event 6 (t = 15): Splashdown & Recovery
- Power terminates; payload(s) recovered
**TE Matrix**

<table>
<thead>
<tr>
<th>Event</th>
<th>Time On</th>
<th>Units</th>
<th>Dwell Time</th>
<th>Units</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSE 1</td>
<td>T-0</td>
<td>(T-X) (sec)</td>
<td>330 (sec)</td>
<td>(sec)</td>
<td>Main Payload power</td>
</tr>
<tr>
<td>GSE 2</td>
<td>UNUSED</td>
<td>(T-X) sec</td>
<td>(sec)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TE-R</td>
<td>T+102</td>
<td>(T+X) (sec)</td>
<td>228 (sec)</td>
<td>(sec)</td>
<td>Deployment Trigger</td>
</tr>
<tr>
<td>TE-1</td>
<td>T+102</td>
<td>(T+X) (sec)</td>
<td>228 (sec)</td>
<td>(sec)</td>
<td>Additional component power</td>
</tr>
<tr>
<td>TE-2</td>
<td>UNUSED</td>
<td>(T+X) (sec)</td>
<td>(sec)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TE-3</td>
<td>UNUSED</td>
<td>(T+X) (sec)</td>
<td>(sec)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Mission Overview: Success Criteria

Minimum Success Criteria:
– Successfully demonstrate CubeSat-like solar array deployment method
– Successfully retract solar array
– Record video of deployment

Comprehensive Success Criteria:
– Power a sensor suite using power generated by the deployed solar array
– Characterize the efficiency of the solar array over the entire flight
**Top Level Requirements:**

- At the PDR level you should highlight the most critical (Top 3?) system and project level requirements and how they will be verified prior to flight (an example below).

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>The deployable solar array shall successfully deploy</td>
<td>Test</td>
<td>Array will be tested and design iterated until it demonstrates reliable success</td>
</tr>
<tr>
<td>A video of the deployment while in flight will be recorded</td>
<td>Demonstration</td>
<td>The functioning video recording system will be demonstrated prior to flight.</td>
</tr>
<tr>
<td>The full system shall fit on a single RockSat-X deck</td>
<td>Inspection</td>
<td>Visual inspection will verify this requirement</td>
</tr>
<tr>
<td>The system shall survive the vibration characteristics prescribed by the RockSat-X program.</td>
<td>Test</td>
<td>The system will be subjected to these vibration loads in June during testing week.</td>
</tr>
</tbody>
</table>
De-Scopes and Off-Ramps

• Currently de-scoped the fan deployment method
2.0 System Overview

Kris Stone
Design Overview: Science Design

• Main goal is to deploy a solar array from a CubeSat form factor with the goal of collecting solar energy. Implementation of the NASA XSAS model will be emphasized.

• Primary sensor will be a MPPT solar tracking management system which will monitor the power generated by the array, needed to characterize array performance. We will also have an RTD temperature sensor monitoring the array temperature for efficiency vs. temp.

• Power generated by the array will be used to charge an onboard lithium ion battery to power a load
Design Overview: Engineering Design

- **Structure**
  - Housing will simulate CubeSat form factor and will protect internal electrical components from launch loads, vacuum, reentry heating, and splashdown.
  - Solar array has to withstand vacuum environment, has to be able to successfully extend and retract from the payload.
- **Sensors**
  - Additional sensors could include a camera to record array deployment and an LED array powered by energy generated from solar array.
  - Possible Strain gages attached to the panel to measure axial stress in hopes to characterize flight-like environment.
- **Power**
  - Onboard systems to be powered by NASA batteries and potential power generated from the deployable solar array.
Electrical Functional Block Diagram
Electrical Components Pinout

- **NASA PWR TELEM**
  - PIN_1_GSE_PWR
  - PIN_2_GSE_REDUN
  - PIN_6_GND
  - PIN_7_GND
  - PIN_13_RS232
  - PIN_14_RS232

- **9V Buck Regulator**
  - INPUT
  - OUTPUT
  - ADJ_GND

- **Arduino Mega 2560**
  - 5V
  - GND
  - VIN
  - TX(D1)
  - RX(D0)
  - SDA(D20)
  - SCL(D21)
  - MOSI(D50)
  - MOSI(D51)
  - SCK(D52)
  - CS(D53)

- **Sunny Buddy Solar Charger**
  - SOLAR_IN
  - BATT_IN
  - LOAD_SENSOR
  - GND
  - +850mAh Li-ion
  - +Solar Panel

- **MAX31865 RTD AMP**
  - 5V
  - GND
  - SCK
  - MOSI
  - CS

- **INA219 Current Sensor**
  - 5V
  - GND
  - SDA
  - SCL

- **SD Card**
  - 5V
  - GND
  - SCK
  - MOSI
  - CS

- **Camera**
  - 5V
  - GND
  - RX
  - TX
Payload Deck Electronics Layout (Rough)
System Overview: Description of Partnerships

- Met with Andrew Dahir, of CU Boulder on his work with manufacturing solar panels from cells
  - Advising role
- Met with NGIS, others
  - Advising role, funding source
System Overview: Special Requests

- We would request to despin as much as possible
  - For pointing, an orientation that results in the solar array pointing in the direction of the sun would be ideal
- Possible on-board battery usage?
  - Lithium Ion?
    - To be used for charging / discharging from solar panel.
- Do we have to retract solar panel?
3.0 Subsystem Design

Morgan McCaffrey, Nicholas Jones, Alex Halberg, Alex Petsopoulos
## Subsystem Design: Concept Downselect

<table>
<thead>
<tr>
<th>Selection criteria</th>
<th>Weight</th>
<th>Accordion</th>
<th>XSAS</th>
<th>The Fan</th>
<th>CubeSnap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packing efficiency</td>
<td>9</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Mechanical simplicity</td>
<td>6</td>
<td>9</td>
<td>9</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Deployment time</td>
<td>3</td>
<td>9</td>
<td>9</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Low Cost</td>
<td>1</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Lots of failure points</td>
<td>-6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Ease of electrical integration</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Ease of retraction</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Innovative/pizzazz/cool</td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Low Weight</td>
<td>1</td>
<td>6</td>
<td>6</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total score</strong></td>
<td>11</td>
<td><strong>192</strong></td>
<td>168</td>
<td>156</td>
<td></td>
</tr>
<tr>
<td><strong>Rank</strong></td>
<td></td>
<td>1</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

![Diagram of XSAS concept]

![Diagram of Accordion concept]

![Diagram of The Fan concept]

![Diagram of CubeSnap concept]

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**PDR 2019**
Subsystem Design: XSAS

• Benefits
  – High packing efficiency
  – Fast deployment time
  – Ease of actuation

• Difficulties
  – Complex hinge and linkage design
Subsystem Design: XSAS

- Current CAD Concept
XSAS Design

Electronics Box

XSAS Deployer

RockSat-X@VT
Before Deployment

Undeployed
XSAS Design

RockSAT-X@VT
After Deployment
Deployed
**Subsystem Design: Motor Selection**

- To extend the solar array, our design will use a linear actuator with the potential assistance of a motor. Below is the comparison of the researched units.

<table>
<thead>
<tr>
<th></th>
<th>Actuonx L16 Actuator</th>
<th>PQ12 Linear Actuator</th>
<th>RJX FS-0521HV</th>
<th>NEMA 17</th>
<th>HS-646</th>
<th>HS-805MG</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operating Voltage (V)</strong></td>
<td>5-7.4</td>
<td>6</td>
<td>6-8.4</td>
<td>2.8</td>
<td>6-7.4</td>
<td>4.8-6</td>
</tr>
<tr>
<td><strong>Torque (kg/cm)</strong></td>
<td>@4 mm/s - 175N</td>
<td>@6 mm/s - 40N</td>
<td>@6 - 17</td>
<td>3.7</td>
<td>@6 - 9.6</td>
<td>@4.8 - 19.8</td>
</tr>
<tr>
<td></td>
<td>@7 mm/s - 75N</td>
<td>@7.4 - 19.5</td>
<td>@7.4 - 11.6</td>
<td>@6 - 24.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>@8.4 - 21.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Weight (g)</strong></td>
<td>56</td>
<td>15</td>
<td>68</td>
<td>285</td>
<td>60</td>
<td>197</td>
</tr>
<tr>
<td><strong>Dimensions (mm)</strong></td>
<td>50</td>
<td>20</td>
<td>40x20x37</td>
<td>42.3x42.3x38</td>
<td>41.8x21x40</td>
<td>65.79x29.97x57.4</td>
</tr>
</tbody>
</table>
Selected Actuonix L16 Actuator

Benefits:
- Lightweight, 56g
- Ample force 75 - 175N, varying with speed
- Large voltage range, 5 - 7.4V
- Multiple sizes options, similar specs

Drawbacks:
- Somewhat expensive, $70, though somewhat inevitable
- Would require gearing to fully extend array
Subsystem Design: Linear Actuator Controlling

- Controlled by relays
  - Relays triggered by Arduino timing
- Primary voltage/current modulation prior to relay
- Diodes to reduce current spikes
- Current limiting to prevent draw from stall
Subsystem Design: Solar Array

- Array will consist of 4 panels, each with 2 cells
- Will use manufacturing method employed on MinXSS and QB50-Challenger cubesats
- Subsystem Design not final: need to finalize placement of RTD sensor

<table>
<thead>
<tr>
<th>Cell</th>
<th>Vendor</th>
<th>Voltage (V)</th>
<th>Current (mA)</th>
<th>Power (Per Cell) (W)</th>
<th>Power (On Array, In Series) (W)</th>
<th>Weight (g)</th>
<th>Estimated Total Subsystem weight (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>XTJ Prime</td>
<td>SpectroLab</td>
<td>2.406</td>
<td>455</td>
<td>1.095</td>
<td>8.758</td>
<td>2.184</td>
<td>~0.4</td>
</tr>
</tbody>
</table>
Subsystem Design: On-board Electronics

Principle operation requirements

• Step down NASA voltage to ~7 - 12V
• Efficiently collect solar energy and store in a lithium ion battery
• Monitor output current and voltage from solar panel
• Monitor temperature of solar array
• Record images of solar panel deployment
9V, 2.5A Step Down Voltage Regulator (Pololu)

- Max input voltage = 38V
- Nominal output = 9V
- Up to 2.5A cont.
- Reverse voltage protection
Current Sensing Components

- Voltage / Current Sensor (INA219) Adafruit breakout board. To be used with Sunny Buddy Solar Charger.
  - Max current reading ~3.1A
  - Max voltage reading ~26V
  - Operating voltage 3.3V - 5V
  - I2C communication protocol (Arduino Mega)
Open JP2 and Close JP1 to measure current with INA219 sensor
850mAh Lithium Ion Battery

- Outputs nominal 3.7V @ 850mAh
- Terminates with standard JST-PH connector
- Built in protection for over voltage and over current
- Size: 44.45mm x 34.79mm
MPPT (Maximum Power Point Tracking)

• Ability to achieve maximum power transfer from the solar panel to the load.

• The amount of falling sunlight incident on the solar panel is highly variable.

• MPPT effectively changes the load “seen” by the solar panel to produce the highest OC voltage to achieve max power transfer.
MAX31865 RTD PT100 Amplifier

- Internal resistor value changes with temperature change (100 ohms @ 0 deg-C)

- Communicates via SPI, level shifter is included on breakout.
TTL Serial JPEG Camera

- Frame speed 640x480 fps
- 60 deg viewing angle
- Monitoring distance 10m - 15m max
- Current draw 75mA
Data Rate and Communication Protocol

- 9600 baud will be sufficient for the following sensors
  - Temperature probe (RTD)
  - Watt meter
- 38400 baud will be necessary for the camera
  - Arduino Mega has 3 serial outputs so this should be fine
- More info on baud rates per each sensor can be found in their respective data sheets

- UART will be the communication protocol used in this experiment
- We are positive it will work for the camera and temperature probe
- Wattmeter will use I2C protocol with SDA and SCL provided by Arduino
Mission Pseudocode

BEGIN
Initialize Arduino Mega
Wait for skirt separation
Skirt Separation
Deploy Solar Panel
Take Image
Loop
Take Watt output and temperature data
Log to SD Card
Transmit over NASA Telemetry
END
Power Off
Take Image
Retract Solar Panel
$t = 4.5\text{ min}$
Main science aspects would be centered around testing the efficiency of our solar panel compared to on-Earth measured data.
- Monitoring temperature of the panels and comparing this to expected I-V curves
  - As these panels heat up the efficiency is expected to decrease drastically.
- May include some MLI material on a portion of the panel to determine the heat mitigation performance and whether this could be a viable passive cooling feature for future solar panels.
## Power Budget

### Virginia Tech - Power Budget

**Date:** 12/20/18

<table>
<thead>
<tr>
<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>GSE1</td>
<td>9V Voltage Regulator</td>
<td>28.0</td>
<td>2.50</td>
<td>0</td>
<td>5.5</td>
<td>70.0</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>Arduino Mega 2560</td>
<td>9.0</td>
<td>0.75</td>
<td>0</td>
<td>5.5</td>
<td>6.75</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>RTD / Amplifier</td>
<td>3.3</td>
<td>0.02</td>
<td>0</td>
<td>5.5</td>
<td>0.07</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Current Sensor</td>
<td>6.0</td>
<td>0.01</td>
<td>0</td>
<td>5.5</td>
<td>0.06</td>
<td>0.00</td>
</tr>
<tr>
<td>TEB</td>
<td>Camera</td>
<td>3.3</td>
<td>0.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TE1</td>
<td>Actuonix Li16 Actuator</td>
<td>6.0</td>
<td>1.00</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

### Total

<table>
<thead>
<tr>
<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>GSE 1/2 Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TE1/2/3/R Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>76.88</td>
<td>0.30</td>
</tr>
</tbody>
</table>

- Total Power Capacity: 0.50
- Over/Under: 0.20

# of Flights Margin: 3.3
4.0 Risk Matrices

Anthony DeFilippis
Risk Matrix

RISK 1: Ability to test deployment design as close to in-situ conditions will be degraded if unable to acquire space-grade solar cells

RISK 2: Solar array performance is reduced due to breakages during launch loads

RISK 3: Operability of solar cells will not be able to be determined due to incorrect alignment

RISK 4: Will be unable to test solar efficiency if deployment fails
5.0 Test/Prototyping Plan

Nicholas Jones / Anthony DeFilippis
Test/Prototyping Plan: Solar Array

1. Inspect solar cells visually and evaluate electrical operability under direct sunlight
   a. Verify cells are working properly
2. Construct panels and re-verify electrical operability
   a. Verify that no errors occurred in the mounting process
   b. Each panel should be tested as it is completed so that any mistakes that are made can be corrected before they affect the other panels
3. Test panels on deployment mechanism and verify electrical operability
   a. Verify no errors occurred in the mounting process
   b. Establish minimum performance values for comparison to in-flight performance
4. Conduct vacuum, vibrational, and thermal testing to verify space readiness
Test/Prototyping Plan: Solar Array

Initial mock-up will match dimensions from CAD model, will be used to demonstrate deployment mechanism.

1. Material Procurement
   a. 3D-print all components (quick to assemble and test)

1. Assembly
   a. Glue static components together (parts that aren’t moving)
      i. Exterior plates to each other, hinges to panels
   b. Create pinned joints between the linkages and hinges to allow for rotation

1. Final model
   a. Aluminum sheets and components, bolted and soldered, interior insulation to mitigate vibrational and thermal hazards
Test/Prototyping Plan: Deployment System

1. 3D-print mechanical deployment system (ABS, Zortrax M200)
2. Test and iterate design based on concepts learned
   a. With stand-in solar array
3. CAD → final manufacturing (machining) with 6061 aluminum
   a. Ensure system is easily integratable, serviceable
4. Continue to test final system with real solar array
5. Conduct/Model vibration testing; main concern: high launch loading impact on integrated solar cells
Preliminary 3D-printed prototype with CAD comparison.
*Due to printing difficulties, scissor bars are not shown in initial prototype
**This is a 50% scale model, demonstrating prototyping capability and partial proof-of-concept. ***Full prototype production will conclude in late Jan. - early Feb.
6.0 Testing Plan

Tony DeFilippis / Simran Singh
Testing Plan: Mechanical Testing

• Component will be weighed and updated in CAD as they are procured to ensure weight requirements met

• Deployer will be tested in several orientations to ensure reliability and consistency

• Will potentially use Orbital ATK vibration facilities to ensure deployer and thermal knife circuits do not fire prematurely
Testing Plan: Electrical Testing

• Individual breadboard sensor testing of all breakout boards.
  ○ Mid February
• Combined systems test with all breakout boards interfaced as one.
  ○ Late February
  ○ Interface with software for HITL test
• Solar panel charging circuitry tested during optimal atmospheric conditions
  ○ Early March
Testing Plan: Software Testing

- Derive unit tests for all helper functions derived for each breakout sensor.
- Integrate entire software suite with hardware to test system functionality.
- Write and test telemetry handling over serial
  - Mid March
Testing Plan: System Level Testing

- Deployer will be tested will linear actuator
- Solar panels will be mounted and charging will be tested
- System deployment and retraction tested
- Software and timer-event triggered deployment will be tested
7.0 User Guide Compliance

Tony DeFilippis
## 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>Will conform</td>
</tr>
<tr>
<td>Weight 30.0+/- 1.0 (15.0 +/- 0.5) lbs?</td>
<td>Will conform</td>
</tr>
<tr>
<td>Max Height &lt; 10.75” (5.13”)</td>
<td>Will conform</td>
</tr>
<tr>
<td>Bottom of deck has flush mount hardware?</td>
<td>Will conform</td>
</tr>
<tr>
<td>Within Keep-Out Zone</td>
<td>Will conform</td>
</tr>
<tr>
<td>Using &lt; 10 A/D Lines</td>
<td>Yes</td>
</tr>
<tr>
<td>Using/Understand Parallel Line</td>
<td>N/A</td>
</tr>
<tr>
<td>Using/Understand Asynchronous Line</td>
<td>YES, at 9600 Baud</td>
</tr>
<tr>
<td>Using X GSE Line(s)</td>
<td>YES, GSE-1</td>
</tr>
<tr>
<td>Using X Non-Redundant PWR Lines (TE-1, TE-2, TE-3)</td>
<td>YES, TE-1</td>
</tr>
<tr>
<td>Using X Redundant Power Lines (TE-R)</td>
<td>YES, TE-R</td>
</tr>
<tr>
<td>Using &lt; 1 Ah</td>
<td>YES</td>
</tr>
<tr>
<td>Using &lt;= 28 V</td>
<td>YES</td>
</tr>
<tr>
<td>Using RF (If yes, list frequency and TX Power)</td>
<td>N/A</td>
</tr>
<tr>
<td>Using deployable?</td>
<td>YES, Solar Panel Deployment Mechanism</td>
</tr>
<tr>
<td>Whole team consists of US Persons</td>
<td>NO, we have 1 Indian Citizen</td>
</tr>
<tr>
<td>Using ITAR and/or Export Controlled hardware</td>
<td>NO</td>
</tr>
</tbody>
</table>
## User Guide Compliance: Power Interface

<table>
<thead>
<tr>
<th>Power Pin</th>
<th>Function</th>
<th>Intended Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GSE 1</td>
<td>Power Payload Computer</td>
</tr>
<tr>
<td>2</td>
<td>Timer Event Redundant (TE-RA)</td>
<td>Power Cameras / RTD</td>
</tr>
<tr>
<td>3</td>
<td>Timer Event Redundant (TE-RB)</td>
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</tr>
<tr>
<td>4</td>
<td>Timer Event 1 (TE-1)</td>
<td>Solar Panel Deployment</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td>Unused</td>
</tr>
<tr>
<td>6</td>
<td>GND</td>
<td>GND</td>
</tr>
<tr>
<td>7</td>
<td>GND</td>
<td>GND</td>
</tr>
<tr>
<td>8</td>
<td>GND</td>
<td>Unused</td>
</tr>
<tr>
<td>9</td>
<td>GSE 2</td>
<td>Unused</td>
</tr>
<tr>
<td>10</td>
<td>Timer Event 2 (TE-2)</td>
<td>Unused</td>
</tr>
<tr>
<td>11</td>
<td>Timer Event 3 (TE-3)</td>
<td>Unused</td>
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<td>12</td>
<td>GND</td>
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<tr>
<td>13</td>
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<tr>
<td>14</td>
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<tr>
<td>15</td>
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</table>
## User Guide Compliance: Telemetry Interface

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1</td>
<td>Analog 1</td>
<td>Unused</td>
</tr>
<tr>
<td>2</td>
<td>Analog 2</td>
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<tr>
<td>3</td>
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<tr>
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<tr>
<td>8</td>
<td>Analog 8</td>
<td>Unused</td>
</tr>
<tr>
<td>9</td>
<td>Analog 9</td>
<td>Unused</td>
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<tr>
<td>10</td>
<td>Analog 10</td>
<td>Unused</td>
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<tr>
<td>11</td>
<td>Parallel Bit 1 (MSB)</td>
<td>Unused</td>
</tr>
<tr>
<td>12</td>
<td>Parallel Bit 2</td>
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<tr>
<td>13</td>
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<td>15</td>
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<tr>
<td>16</td>
<td>Parallel Bit 6</td>
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</tr>
<tr>
<td>17</td>
<td>N/C</td>
<td>N/C</td>
</tr>
<tr>
<td>18</td>
<td>Ground</td>
<td>GND</td>
</tr>
<tr>
<td>19</td>
<td>Ground</td>
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<tr>
<td>20</td>
<td>Parallel Bit 7</td>
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<tr>
<td>21</td>
<td>Parallel Bit 8</td>
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<td>22</td>
<td>Parallel Bit 9</td>
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<tr>
<td>23</td>
<td>Parallel Bit 10</td>
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<td>24</td>
<td>Parallel Bit 11</td>
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<td>26</td>
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<td>27</td>
<td>Parallel Bit 14</td>
<td>Unused</td>
</tr>
<tr>
<td>28</td>
<td>Parallel Bit 15</td>
<td>Unused</td>
</tr>
<tr>
<td>29</td>
<td>Parallel Bit 16 (LSB)</td>
<td>Unused</td>
</tr>
<tr>
<td>30</td>
<td>Parallel Read Strobe</td>
<td>Unused</td>
</tr>
<tr>
<td>31</td>
<td>N/C</td>
<td>N/C</td>
</tr>
<tr>
<td>32</td>
<td>RS-232 Data (TP1)</td>
<td>Telemeterize Payload Data</td>
</tr>
<tr>
<td>33</td>
<td>RS-232 GND (TP2)</td>
<td>Data Ground Communication</td>
</tr>
<tr>
<td>34</td>
<td>N/C</td>
<td>N/C</td>
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<tr>
<td>35</td>
<td>N/C</td>
<td>N/C</td>
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<tr>
<td>36</td>
<td>Ground</td>
<td>GND</td>
</tr>
<tr>
<td>37</td>
<td>Ground</td>
<td>GND</td>
</tr>
</tbody>
</table>
8.0 Project Management Plan (PMP)

Nicholas Corbin
Team Mentors

- Dr. Kevin Shinpaugh, VT PI
- Dr. Jonathan Black, VT PI
- Andrew Dahir, CU
- Ben Hekman, Industry Mentor
Team Organization Chart

Anthony DeFilippis
Team Lead

Electrical Sub-Team

- Kris Stone
  Team Lead
- Jonathan Grabski
  Team Member
- Nicholas Jones
  Team Member
- Alex Petsopoulos
  Team Member
- Morgan McCaffrey
  Team Member

Mechanical Sub-Team

- Alex Halberg
  Team Co-Lead
- Dana Gilroy
  Team Member
- Hemanth Katragadda
  Team Member
- Surabhi Srivastava
  Team Member
- Brennan Rausch
  Team Member
- Simran Singh
  Team Co-Lead
- Andrew Dev
  Team Member
- Tara Mattimiro
  Team Member
- Trevor Bondi
  Team Member

Mentors

- Dr. Kevin Shinpaugh
- Dr. Jonathan Black
- Ben Hekman
Preliminary Schedule

- **NASA Design Review Process:**
  - Conceptual Design Review
    - 26 October 2018
  - Preliminary Design Review
    - 15 November 2018 (5PM MT / 7PM EST)
  - Critical Design Review
    - December 20th, 2018
  - Classes end Dec 14th

- **Team Mission Schedule:**
  - Classes start January 22nd
  - All design and CAD work completed
    - 31 January 2019
  - Payload subsystem testing completed
    - 1 March 2019
  - Payload integration and system testing completed
    - 25 April 2019
  - Integration and testing at Wallops
    - June 2019
# Monetary Budget

## RockSat-X 2019 Detailed Budget

### Mission Expenses

<table>
<thead>
<tr>
<th>Critical Expenses</th>
<th>Amount</th>
<th>Still to Pay</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earnest Deposit</td>
<td>$2,000.00</td>
<td>$0.00</td>
<td>RockSat-X Flight Cost</td>
</tr>
<tr>
<td>Launch Fee Installment 1</td>
<td>$6,000.00</td>
<td>$6,000.00</td>
<td>RockSat-X Flight Cost</td>
</tr>
<tr>
<td>Launch Fee Installment 2</td>
<td>$6,000.00</td>
<td>$6,000.00</td>
<td>RockSat-X Flight Cost</td>
</tr>
<tr>
<td>Payload Component Estimate</td>
<td>$3,000.00</td>
<td>$3,000.00</td>
<td>Estimate</td>
</tr>
<tr>
<td>Payload Manufacturing Estimate</td>
<td>$1,000.00</td>
<td>$1,000.00</td>
<td>Estimate</td>
</tr>
</tbody>
</table>

### Non-Critical Expenses

<table>
<thead>
<tr>
<th>Non-Critical Expenses</th>
<th>Amount</th>
<th>Still to Pay</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing Estimate (June Travel)</td>
<td>$1,600.00</td>
<td>$1,600.00</td>
<td>7 nights - Chincoteague, VA</td>
</tr>
<tr>
<td>Housing Estimate (August Travel)</td>
<td>$1,600.00</td>
<td>$1,600.00</td>
<td>7 nights - Chincoteague, VA</td>
</tr>
</tbody>
</table>

**Total Expenses:** $21,200.00
**Balance:** -$7,654.15

### Project Funding

<table>
<thead>
<tr>
<th>Organization</th>
<th>Amount</th>
<th>Current Balance</th>
<th>Fund Number</th>
<th>Expires?</th>
<th>Expr. Date</th>
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<tbody>
<tr>
<td>VT Foundation</td>
<td>$2,545.85</td>
<td>$2,545.85</td>
<td>876202</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>AOE Department</td>
<td>$5,000.00</td>
<td>$5,000.00</td>
<td>118161/EF1925</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>VSGC</td>
<td>$5,000.00</td>
<td>$5,000.00</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orbital / Northrup Grumman</td>
<td>TBD</td>
<td>TBD</td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>SEAC</td>
<td>$1,000.00</td>
<td>$1,000.00</td>
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</table>

**Total Funding:** $13,545.85
## Contact Matrix

### Virginia Tech

#### 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 Lead</td>
<td>Anthony DeFilippis</td>
<td>520-820-5378</td>
<td>520-820-5378</td>
<td>Yes</td>
<td><a href="mailto:dtony@vt.edu">dtony@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Hemanth Katragadda</td>
<td>978-844-6561</td>
<td>978-844-6561</td>
<td>Yes</td>
<td><a href="mailto:hemak96@vt.edu">hemak96@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Alex Petsopoulos</td>
<td>703-955-6770</td>
<td>703-955-6770</td>
<td>Yes</td>
<td><a href="mailto:palex22@vt.edu">palex22@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Trevor Bondi</td>
<td>757-761-5208</td>
<td>757-761-5208</td>
<td>Yes</td>
<td><a href="mailto:bondi215@vt.edu">bondi215@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Brennan Rausch</td>
<td>757-759-0588</td>
<td>757-759-0588</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></td>
<td>Nicholas Jones</td>
<td>757-751-5263</td>
<td>757-751-5263</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></td>
<td>Tara Mattmire</td>
<td>571-449-0757</td>
<td>571-449-0757</td>
<td>Yes</td>
<td><a href="mailto:tara98@vt.edu">tara98@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Surabhi Srivastava</td>
<td>540-597-9329</td>
<td>540-597-9329</td>
<td>Yes</td>
<td><a href="mailto:suv98@vt.edu">suv98@vt.edu</a></td>
<td>Indian</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Andrew Dev</td>
<td>607-592-9315</td>
<td>607-592-9315</td>
<td>Yes</td>
<td><a href="mailto:adev@vt.edu">adev@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Jonathan Grabski</td>
<td>703-946-2194</td>
<td>703-946-2194</td>
<td>Yes</td>
<td><a href="mailto:jon20@vt.edu">jon20@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Morgan McCaffrey</td>
<td>703-919-7541</td>
<td>703-919-7541</td>
<td>Yes</td>
<td><a href="mailto:Mccaff95@vt.edu">Mccaff95@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Dana Gilroy</td>
<td>571-606-2335</td>
<td>571-606-2335</td>
<td>Yes</td>
<td><a href="mailto:danag20@vt.edu">danag20@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Mechanical Team Co-Lead</td>
<td>Simran Singh</td>
<td>804-549-3235</td>
<td>804-549-3235</td>
<td>Yes</td>
<td><a href="mailto:simran10@vt.edu">simran10@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Mechanical Team Co-Lead</td>
<td>Alex Halberg</td>
<td>650-575-0382</td>
<td>650-575-0382</td>
<td>Yes</td>
<td><a href="mailto:alexh96@vt.edu">alexh96@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Electrical Team Lead</td>
<td>Kristofer Stone</td>
<td>540-292-7083</td>
<td>540-292-7083</td>
<td>Yes</td>
<td><a href="mailto:kristo7@vt.edu">kristo7@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
</tbody>
</table>
## Team Availability Matrix

### Virginia Tech

**Fall 2018 RS-X Team Availability Matrix**

<table>
<thead>
<tr>
<th>Time</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:00 AM</td>
<td>4</td>
<td>4</td>
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<td>4</td>
<td>4</td>
</tr>
<tr>
<td>8:00 AM</td>
<td>4</td>
<td>4</td>
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<tr>
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<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

**PLEASE USE MOUNTAIN TIME ZONE TIMES**

Please Place priority levels for times you are available. This is done by simply typing a 1,2,3, or 4 in each clear box.

### Example

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Highest Priority</th>
<th>Lowest Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Risks/Worries

- Deployment will be complicated
  - Novel payload, need to evaluate COTS solutions
Conclusion

• A low-cost CubeSat-sized solar panel deployment mechanism will provide a good alternative to commercial solutions
• From CDR
  – Develop deployment solutions