Virginia Tech RockSat-X
2014
Delta Critical Design Review

Virginia Tech
Presented by David Black, Brian McCarthy, Bas Welsh
February 7, 2013
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

David Black
Mission Objectives:

• Test deployment of the Space Pressure Sensor (SPS) Aperture Cover Release Mechanism (SPS ACRM)
  – Thermocouple, video, and contact plate data
  – Successful data transmission and storage
    • Transmit thermocouple and contact plate data
  – Mechanical and thermal securing for reentry

• Utilize Optical Nitric Oxide Sensor (ONS) for NO concentration data collection in high altitudes
  – Optimal sensor orientation
  – Successful data transmission and storage
  – Mechanical and thermal securing for reentry

• Record panoramic video for virtual reality simulation (VRE)
  – In partnership with a.i. solutions
  – Storing raw video for post mission processing and evaluation
  – Mechanical and thermal securing for reentry and submerged environment
Theory and Concepts

- **SPS Aperture Cover Release Mechanism**
  - PI: Dr. Gregory Earle, VT, Robbie Robertson, VT
  - Cover release mechanism for the primary instrument of the VT LAICE CubeSat mission (2015)
  - PI seeking flight heritage for final design
  - Prototype flight heritage on RockSat-X 2012
  - 3 methods to verify deployment success
Theory and Concepts

• Optical Nitric Oxide Sensor (ONS)
  – PI: Dr. Scott Bailey, VT
  – Measure concentration of NO as a function of altitude
  – Flight heritage
    • RockSat-C 2011 (NOIME)
    • RockSat-X 2012 (NODDEX)
Theory and Concepts

• Flight video recording for virtual reality simulation
  – Record panoramic video data of RockSat-X flight (4 GoPro Hero3+ Black cameras)
  – Record video data of rest of payload (1 GoPro Hero3+ Black camera)
  – Data will be processed post flight
  – Processed flight video will be used for virtual reality experience with an Oculus Rift
Virginia Tech RockSat-X 2014 ConOps

- **t ≈ 0 min**
  - t = 0 min
  - Altitude: 52 km
  - End of Malamute Burn
  - t ≈ 0.5 min
  - Altitude: 52 km
  - All systems on (T–10 min)
  - Panoramic camera system on (T–0.5 min)
  - Begin data collection (T–3 min)

- **t ≈ 1.2 min**
  - t = 1.2 min
  - Altitude: ~75 km
  - Skirt Released

- **t ≈ 2.67 min**
  - Altitude: ~145 km
  - SPS ACRM Open

- **t ≈ 3.3 min**
  - Altitude: ≈ 156.1 km
  - Apogee

- **t ≈ 5.5 min**
  - Altitude: 75 km
  - Reentry

- **t ≈ 7.8 min**
  - Chute Deploys

- **t ≈ 15 min**
  - Splash Down

- **t ≈ 2014**

- **t ≈ 2.67 min**
  - Altitude: ~145 km
  - SPS ACRM Open

- **t ≈ 3.3 min**
  - Altitude: ≈ 156.1 km
  - Apogee

- **t ≈ 5.5 min**
  - Altitude: 75 km
  - Reentry

- **t ≈ 7.8 min**
  - Chute Deploys

- **t ≈ 15 min**
  - Splash Down
## Concept of Operations

### Virginia Tech RockSat-X 2014 Timer Events

**Date:** 2/3/13

<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>600</td>
<td>(T-X) (s)</td>
<td>Flight</td>
<td>(s)</td>
<td>Main power to payload; power to power distribution board, boot flight computer, power to ACRM thermal knife board</td>
</tr>
<tr>
<td>GSE 2</td>
<td>-180</td>
<td>(T-X) (s)</td>
<td>Flight</td>
<td>(s)</td>
<td>Redundant power to payload</td>
</tr>
<tr>
<td>TE-1</td>
<td>180</td>
<td>(T+X) (s)</td>
<td>Flight</td>
<td>(s)</td>
<td>N/C</td>
</tr>
<tr>
<td>TE-2</td>
<td>180</td>
<td>(T+X) (s)</td>
<td>Flight</td>
<td>(s)</td>
<td>N/C</td>
</tr>
<tr>
<td>TE-3</td>
<td>180</td>
<td>(T+X) (s)</td>
<td>Flight</td>
<td>(s)</td>
<td>N/C</td>
</tr>
<tr>
<td>TE-R</td>
<td>-30</td>
<td>(T+X) (s)</td>
<td>Flight</td>
<td>(s)</td>
<td>Power to VRE Camera Power Relay</td>
</tr>
</tbody>
</table>
Expected Experiment Results

- SPS ACRM will open properly
  - At $T + 160$ seconds (2.67 min), we will see:
    - Proper voltage spike from thermocouple
    - Latch contact plates will show proper voltage change
    - Video will verify other data sources

- Nitric Oxide concentrations at high altitude
  - Correlating to Dr. Bailey’s preliminary data
  - Compare to NOIME and NODDEXX flight results
  - Will get clarification from Dr. Bailey on expected results
Mission Requirements

• Project requirements
  – The system shall conform to the requirements set forth in the 2013 RockSat-X User Guide.
  – System shall meet power transmission requirements to all sensors.
  – System shall transmit data via NASA Wallops telemetry.
  – System should collect (3) data sources verifying optimal SPS aperture cover release mechanism deployment from the following sources: thermocouple, video, and latch contact sensors.
  – System should orient ONS for optimal data collection (TBD whether on 180 degree line or offset).
  – System should successfully record and store panoramic video data throughout mission duration prior to splashdown.
  – System shall mechanically and thermally secure sensors and integral components for reentry and recovery.
Mission Requirements

• Minimum Success Criteria
  – System shall collect and transmit (2) data sources verifying optimal SPS aperture cover release mechanism deployment from the following sources: thermocouple and latch contact sensors.
  – System shall collect NO data that is consistent with current global models.
  – System shall successfully record and store panoramic video from at least (2) cameras for some portion of the sounding rocket flight.
  – System shall gain flight heritage for the SPS aperture cover release mechanism.
  – System shall gain flight heritage for the Optical Nitric Oxide Sensor.
2.0 System Overview

David Black, Sebastian Welsh
System Changes Since CDR

• CDR Action Items:
  • Design down to O-ring groove level
  • Address Electrical and Software Designs
  • Develop VRE specifics
  • Add pictures/screenshots of parts we’re using (with part numbers if possible)
  • Fully realize weight budget
  • Put together schedule/milestones
## Top Level Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>The SPS ACRM will open properly and the sensor suite will register the correct verification signals.</td>
<td><strong>Demonstration</strong></td>
<td>Will test and evaluate system in a laboratory environment. Test results will provide basis for post-flight comparison</td>
</tr>
<tr>
<td>Optimal NO sensor orientation and successful data transmission and storage</td>
<td><strong>Demonstration</strong></td>
<td>Will verify calibration with simulation in lab assisted by Dr. Bailey</td>
</tr>
<tr>
<td>The full system shall fit on a single RockSat-X deck.</td>
<td><strong>Inspection</strong></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><strong>Test</strong></td>
<td>The system will be subjected to these vibration loads in June during testing week.</td>
</tr>
</tbody>
</table>
Final Block Diagram
Mechanical Design Overview: Full Payload
Mechanical Design Overview: Full Payload
Mechanical Design Overview: Full Payload
Electrical Design Overview

• Six main electrical elements
  – Power Distribution Board
  – ONS Post-Amplifier Board
  – Thermal Knife Control Board
  – Camera Switch Board
  – Arduino Mega
  – Logomatic Serial Datalogger

• Signals/Lines between shown in Block Diagram
Electrical Design: Power Distribution Board

- 2 power converters to interface NASA GSE power line with rest of payload
  - 1 muRata PS 28 V → 12 V DC/DC converter
    - Sends power to Arduino, thermal knife control board
    - Input Voltage Range: 15 – 36 V
    - Mouser Part Number: 580-7812SRH-C
  - 1 muRata PS 28 V → ±15 V DC/DC converter
    - Sends power to Femto NO sensor amp
    - Input Voltage Range: 18 – 36 V
    - Mouser Part Number: 580-NDTD2415C

![Power Distribution Board Diagram]

![muRata PS 28 V → 12 V (580-7812SRH-C)]

![muRata PS 24 V → ±15 V (580-7812SRH-C)]
Electrical Design: ONS Post Amplifier Board

- Further amplifies NO sensor signal after Femto amplifier
  - 3 Op-Amps
    - Amplify NO sensor signal
    - Digi-Key Part Number: INA126P-ND
  - 3 Trim Pots
    - Set individual op-amp gains
    - 500 Ohm (3009Y-1-501LF)
    - 1000 Ohm (3006W-1-103LF)
    - 10000 Ohm (3006W-1-101LF)

Nitric Oxide Sensor Post-Amplifier Board

Texas Instruments Op-Amp (INA126P-ND)
Bourns Inc. Trim Pot (INA126P-ND)
Electrical Design: Thermal Knife Control Board

- Activates the thermal knives when firing signal is received from flight computer
- 2 of the pictured circuit on board
- Same design as will be flown on the LAICE CubeSat
- In process of testing now; C1 may change in size, but circuit design will remain the same
Electrical Design: Camera Switch Board

- Turns on the cameras at T-30 s (NASA TE-R)
  - 1 Panasonic +28 V Relay Switch
    - Input Voltage Range: 18 – 28 V
    - Interfaced with camera power pins
    - Digi-Key Part Number: INA126P-ND
  - Pins 12 (on/off button) and 30 (GND) control camera power
    - Interface with each camera through GoPro Bus connector
    - Connector Vendor: Cam-Do.com

![Camera Switch Board Diagram]

Texas Instruments Op-Amp (INA126P-ND)  
GoPro Bus connector
Electrical Design: Arduino Mega

- Will utilize an Arduino Mega for our flight computer
  - Input voltage: 7 – 12 V
  - 54 digital I/O pins
  - 15 analog inputs
  - 4 serial ports

- Inputs:
  - 4 digital
    - SPS ACRM Latch Sensors
  - 4 analog
    - ONS signals (3)
    - Thermocouple

- Outputs:
  - 1 digital
    - SPS ACRM Thermal Knife Firing Signal
  - 1 serial (RS232)
    - To NASA TM (TX pin)
    - To Logomatic Datalogger

- Programming flowchart on Slide 27
Electrical Design: Logomatic Datalogger

- Logomatic v2 Serial SD Datalogger
  - Logs all sensor data on a microSD card
  - COTS
  - SparkFun Part Number: WIG-10216

- Inputs:
  - 1 serial
    - Output from Arduino Mega
    - RS232
Software Design:
Description of Partnership

• a.i. solutions
  – Involved with Sounding Rocket Flight Virtual Reality Experiment
    • No experimental involvement prior to flight.
    • After student post-flight processing of video data is completed the processed data will be passed to a.i. solutions for integration into the virtual reality simulation.
    • Virtual reality simulation will be returned to student team.

  – Partner Roles:
    • Distance mentoring of student team
    • Sponsoring the student team
Special Request for NSROC and NASA/Wallops

- For optimal data collection, the ONS will require orientation in the nadir direction
  - As discussed during the CoDR and PDR, this orientation is flexible as we can adjust the ONS within our payload to meet other payloads’ requirements
  - However, we request attitude control to enable nadir orientation throughout a TBD interval (flexible in length but after skirt separation and before re-entry).
Inhibits Request for NSROC and NASA/Wallops

• Request (2) pre-flight inhibits on our payload
  – 1 RBF pin
    • Between NASA GSE-1/GSE-2 and our Power Distribution Board
    • See Block Diagram for location
  – 1 Electrical Inhibit
    • On TE-R line
    • Prevent cameras from activating prior to T – 30 seconds
3.0 Subsystem Design

David Black, Brian McCarthy
SPS ACRM
SPS ACRM Block Diagram

SPS Aperture Cover Release Mechanism

- Thermal Knife Power Board
- NiCr Thermal Knife
- Latch Sensor 1
- Latch Sensor 2
- Latch Sensor 3
- Latch Sensor 4
- Thermocouple

12 V

Thermal Knife Firing Signal

To Arduino

Connection Key:
- Power: 
  - 28 V
  - 5 V
  - 12 V
  - 15 V
- A/D Signal
- Analog
- Digital
- RS232 Signal
- Video Data Signal
- Thermal Knife Firing Signal
SPS ACRM

• **Power Requirements:**
  – 12 V
    • Thermal Knives

• **Mass:**
  – 7.66 lb (overestimate)
  – Chamber and thermocouple brackets currently being machined

• **This design is final.**
  – Currently assembling and testing knife control electronics board.
  – Waiting for ACRM parts to return from plating
ACRM.RSK.1: Data logger fails in-flight, NASA/Wallops telemetry data corrupted; no data received or recovered.
ACRM.RSK.2: The ACRM system cannot survive launch conditions and thus the mission requirements are not met.
ACRM.RSK.3: Mission requirements are not met if cover does not open.
ACRM.RSK.4: Mission requirements are not met if Arduino and/or data loggers fail.
ACRM RSK.5: ACRM sensor components do not survive reentry.
ONS Block Diagram

± 15 V To Arduino

ONS Post-Amp Board
- Op-Amp (50x gain)
- Op-Amp (100x gain)
- Op-Amp (500x gain)

NO Sensor → Femto Amp

Connection Key:
- Power
  - 28 V
  - 5 V
  - 12 V
  - 15 V
- A/D Signal
  - Analog
  - Digital
- RS232 Signal
- Video Data Signal
- Thermal Knife Firing Signal
• **Power Requirements:**
  - ±15 V
    * Femto Amplifier

• **Mass:**
  - 0.271 lb (based on NODDEX mass budget)

• **This design is final.**
  - Still performing testing on refurbished hardware from NODDEX
  - Replacing photodiode and sensor lens/filter
ONS: Risk Matrix

<table>
<thead>
<tr>
<th>Consequence</th>
<th>NO.RSK.1</th>
<th>NO.RSK.2</th>
<th>NO.RSK.3</th>
<th>NO.RSK.4</th>
<th>NO.RSK.5</th>
<th>NO.RSK.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO.RSK.1:</td>
<td>Data logger fails in-flight, Wallops telemetry data corrupted; no data received or recovered.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO.RSK.2:</td>
<td>Pointing of ONS insufficient for useful data collection.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO.RSK.3:</td>
<td>ONS does not survive heating of reentry.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO.RSK.4:</td>
<td>ONS photodiode critically damaged by salt water exposure.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO.RSK.5:</td>
<td>ONS post amplifier fails, no reliable data received.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO.RSK.6:</td>
<td>Femto amplifier fails, no reliable data received.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
VRE Block Diagram

28 V (TE-R)
VRE Camera Box
VRE Camera Box
• 1 Box, 5 Cameras
• Power Requirements:
  – 28 V (NASA TE-R)
  – Internal camera batteries used to power cameras
    • 3.7 V Lithium Ion Batteries
• Mass:
  – 10 lb (overestimate)
• This design is tentatively final.
  – Camera box out for machining
  – Tested internal batteries – after 35 days of charged storage, cameras recorded 2 hours of video using approximately 40% battery.
  – Will evaluate leak and vibration properties
VRE: Risk Matrix

VRE.RSK.1: Camera box breached, camera survives reentry heating but external camera exposed to salt water.
VRE.RSK.2: Camera box breached, camera does not survive reentry heating, storage card survives heating but is exposed to salt water upon splashdown.
VRE.RSK.3: Camera box breached, camera does not survive reentry heating, internal storage card does not survive reentry heating.
# Detailed Weight Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Total Weight (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPS ACRM*</td>
<td>7.65665</td>
</tr>
<tr>
<td>ONS</td>
<td>0.271</td>
</tr>
<tr>
<td>Femto Amplifier</td>
<td>0.484</td>
</tr>
<tr>
<td>VRE*</td>
<td>10</td>
</tr>
<tr>
<td>Flight Electronics*</td>
<td>4</td>
</tr>
<tr>
<td>Payload Deck (2)</td>
<td>6.85</td>
</tr>
<tr>
<td>Ballast Plate</td>
<td>0.73835</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>30</strong></td>
</tr>
<tr>
<td><strong>Over/Under</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

*Overestimate*
### Detailed Power Budget

**Virginia Tech RockSat-X 2014 -- Power Budget**

**Date:** 2/6/13

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Voltage (V)</th>
<th>Max Current (A)</th>
<th>Start Time (T+X) (s)</th>
<th>Time On (s)</th>
<th>Watts</th>
<th>Ah</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femto Amplifier (-)</td>
<td>15.0</td>
<td>0.015</td>
<td>-180</td>
<td>518</td>
<td>0.23</td>
<td>0.0022</td>
</tr>
<tr>
<td>Femto Amplifier (+)</td>
<td>15.0</td>
<td>0.015</td>
<td>-180</td>
<td>518</td>
<td>0.23</td>
<td>0.0022</td>
</tr>
<tr>
<td>ONS Amplifier Board</td>
<td>15.0</td>
<td>0.01</td>
<td>-180</td>
<td>518</td>
<td>0.15</td>
<td>0.0014</td>
</tr>
<tr>
<td>SPS ACRM Board</td>
<td>12.0</td>
<td>0.05</td>
<td>-180</td>
<td>518</td>
<td>0.60</td>
<td>0.0072</td>
</tr>
<tr>
<td>Flight Computer</td>
<td>12.0</td>
<td>0.51</td>
<td>-180</td>
<td>518</td>
<td>6.12</td>
<td>0.0734</td>
</tr>
<tr>
<td>Data Loggers</td>
<td>5.0</td>
<td>0.24</td>
<td>-180</td>
<td>518</td>
<td>1.20</td>
<td>0.0345</td>
</tr>
</tbody>
</table>

|               | Total       | 0.84            |                      |             | 8.52   | 0.12   |

|               | Total Power Capacity |             |                      |             | 1.00   |
|               | Over/Under          |              |                      |             | 0.88   |

| # of Flights Margin | 8.3 |

**Total Power Capacity:** 1.00

**Over/Under:** 0.88

![Cosmo G]
4.0 Prototyping/Analysis Results/Pans

David Black
Prototyping: SPS ACRM

- Most of the hardware is legacy hardware from VT6U
- No prototyping is required as the flight module is being used for testing and evaluation.
- Testing is progressing per the test plan.
Prototyping: ONS

• Most of the hardware is legacy hardware from NODDEX.
• No prototyping is required as the flight sensor and amplifiers are being used for testing and evaluation.
  • Assumes the Femto amplifier continues to pass evaluation.
• Testing is progressing per the test plan.
Prototyping: VRE

- Five GoPro Hero3+ Black cameras were ordered.
- The legacy GoPro Hero from VT6U was used as a prototype to:
  - Evaluate the performance constraints for the built-in battery (successful test).
  - Size the camera box for the flight camera array.
5.0 Manufacturing Plan

David Black
Mechanical Elements: Already Manufactured

• Legacy from VT6U
  – SPS ACRM flight module
    • Everything but the flight baseplate, flight chamber, and thermocouple brackets

• Legacy from NODDEX
  – ONS photodiode housing
Mechanical Elements: To Be Manufactured

- The following parts will be manufactured by the VT AOE shop:
  - SPS ACRM flight baseplate
  - SPS ACRM flight chamber
  - SPS ACRM thermocouple brackets
  - Camera box
- The drawings will be submitted to the AOE shop by early next week.
Mechanical Elements: To Be Ordered

- The following mechanical parts will be ordered from various vendors:
  - Waterproof box for the electronics deck
    - Will be a COTS box
    - Plan to use same manufacturer/style box as was used for the NODDEX payload, but with thicker walls.
      - NODDEX box leaked due to flexing of the side walls under vibration. Thicker walls should eliminate this problem.
Electrical Elements

• Will use the Arduino Mega purchased for VT6U
• Will be evaluating the Logomatic dataloggers from NODDEX
  • Hope to reuse one of them to save money
• Currently breadboarding thermal knife control board
• Will use same amplification board design as NODDEX for ONS
• Will order power distribution board components soon
• Need to determine the sealed throughputs needed on waterproof electronics box
Software Elements

- Software to control data loggers from NODDEX was written for NODDEX
- This code will be built into our flight software package with the Arduino
- Full schedule TBD
  - Barebones software package will be completed by 1 March 2014
  - Full flight software package will be completed by 1 April 2014
6.0 Testing Plan

David Black
Testing Plan

• SPS Aperture Cover Release Mechanism subsystem
  – Waiting on completion of thermal knife control circuit
  – Will test ACRM operation under laboratory conditions
    • Verify definition of optimal sensor data to provide basis for comparison with both pre-flight test data and post-flight data.
  – Will test ACRM operation in a vacuum environment
    • Will utilize the Virginia Tech owned and operated vacuum chamber.
    • Will be conducted after laboratory bench test
  – Will test post-vibration ACRM operation
    • Will utilize a vibration table to approximate (in a very limited fashion) launch conditions.
    • Should highlight any problems with subsystem prior to full payload integration and prior to integration at NASA/Wallops.
  – Will test ACRM operation after extensive thermal cycling
Testing Plan

• **Optical Nitric Oxide Sensor subsystem**
  – Will test refurbished signal amplifier.
    • Amplifier was exposed to salt water after splashdown of NODDEX
    • Amplifier was cleaned but exposure necessitates testing and possible replacement based on test results.
  – Will conduct laboratory tests to verify system design for optimal operation of the ONS during flight.
    • Will test shielding of wire through exposure to a both a smoothly and sharply varying EM field during operation to verify signal isolation.
  – Will conduct simulations for comparison to post-flight data.
    • These will be completed by student team members under the assistance of Dr. Scott Bailey. Dr. Bailey will verify correct simulation results.
Testing Plan

- **Virtual Reality Experiment system**
  - Tested battery performance after a long period of hibernation.
    - Camera was left charged for 35 days.
    - Recorded 2 hours of video using approximately 40% of the battery charge.
  - Will test post-flight processing software.
- **Will test camera array mount**
  - Will utilize a vibration table to approximate (in a very limited fashion) launch conditions.
- **Will test camera box**
  - Thermal testing
  - Water exposure testing
Testing Plan

- **Subsystem level testing:**
  - All mechanical, electrical, and software elements for each of the subsystems will be tested by 1 March 2014.
  - Testing plans have been developed for the SPS ACRM
  - VRE and ONS testing plans are under development

- **System level testing:**
  - All full system tests will be completed by 15 April 2014.
    - Will include system-level vibration testing (single axis, powered)

- **Require two electrical inhibits for Wallops testing:**
  - 1 electrical inhibit on TE-R line (powering cameras)
  - 1 RBF for GSE lines
    - See Slide 16 (Block Diagram) for location
7.0 User Guide Compliance

David Black
### Summary

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Status/Reason (if needed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center of gravity in 1&quot; plane of plate?</td>
<td>YES</td>
</tr>
<tr>
<td>Weight 30.0 +/- 1.0 (15.0 +/- 0.5) lbs?</td>
<td>YES</td>
</tr>
<tr>
<td>Max Height &lt; 12&quot;</td>
<td>YES</td>
</tr>
<tr>
<td>Bottom of deck has flush mount hardware?</td>
<td>YES</td>
</tr>
<tr>
<td>Within Keep-Out Zone</td>
<td>YES, see model on slides 18, 19, 20</td>
</tr>
<tr>
<td>Using &lt; 10 A/D Lines</td>
<td>YES, using 0 analog lines</td>
</tr>
<tr>
<td>Using/Understand Parallel Line</td>
<td>N/A</td>
</tr>
<tr>
<td>Using/Understand Asynchronous Line</td>
<td>YES, at 19200 Baud</td>
</tr>
<tr>
<td>Using X GSE Line(s)</td>
<td>YES, GSE 1 and GSE 2</td>
</tr>
<tr>
<td>Using X Redundant Power Lines (TE-1, TE-2, TE-3)</td>
<td>N/A</td>
</tr>
<tr>
<td>Using X Non-Redundant Power Lines (TE-R)</td>
<td>YES, TE-RA and TE - RB</td>
</tr>
<tr>
<td>Using &lt; 1 Ah</td>
<td>YES</td>
</tr>
<tr>
<td>Using &lt;= 28 V (High Voltage)</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>NO</td>
</tr>
<tr>
<td>Whole team consists of US Persons</td>
<td>YES</td>
</tr>
<tr>
<td>Using ITAR and/or Export Controlled hardware</td>
<td>NO</td>
</tr>
</tbody>
</table>
### 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 to Payload</td>
</tr>
<tr>
<td>2</td>
<td>Timer Event Redundant (TE-RA)</td>
<td>Power to VRE Camera Power Relay @ T - 30 s</td>
</tr>
<tr>
<td>3</td>
<td>Timer Event Redundant (TE-RB)</td>
<td>Power to VRE Camera Power Relay @ T - 30 s</td>
</tr>
<tr>
<td>4</td>
<td>Timer Event 1 (TE-1)</td>
<td>N/C</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td>Tied to Common Ground</td>
</tr>
<tr>
<td>6</td>
<td>GND</td>
<td>Tied to Common Ground</td>
</tr>
<tr>
<td>7</td>
<td>GND</td>
<td>Tied to Common Ground</td>
</tr>
<tr>
<td>8</td>
<td>GND</td>
<td>Tied to Common Ground</td>
</tr>
<tr>
<td>9</td>
<td>GSE 2</td>
<td>Redundant Power to Payload</td>
</tr>
<tr>
<td>10</td>
<td>Timer Event 2 (TE-2)</td>
<td>N/C</td>
</tr>
<tr>
<td>11</td>
<td>Timer Event 3 (TE-3)</td>
<td>N/C</td>
</tr>
<tr>
<td>12</td>
<td>GND</td>
<td>Tied to Common Ground</td>
</tr>
<tr>
<td>13</td>
<td>GND</td>
<td>Tied to Common Ground</td>
</tr>
<tr>
<td>14</td>
<td>GND</td>
<td>Tied to Common Ground</td>
</tr>
<tr>
<td>15</td>
<td>GND</td>
<td>Tied to Common Ground</td>
</tr>
</tbody>
</table>
## Telemetry Interface

<table>
<thead>
<tr>
<th>Telemetry</th>
<th>Function</th>
<th>Intended Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Analog 1</td>
<td>N/C</td>
</tr>
<tr>
<td>2</td>
<td>Analog 2</td>
<td>N/C</td>
</tr>
<tr>
<td>3</td>
<td>Analog 3</td>
<td>N/C</td>
</tr>
<tr>
<td>4</td>
<td>Analog 4</td>
<td>N/C</td>
</tr>
<tr>
<td>5</td>
<td>Analog 5</td>
<td>N/C</td>
</tr>
<tr>
<td>6</td>
<td>Analog 6</td>
<td>N/C</td>
</tr>
<tr>
<td>7</td>
<td>Analog 7</td>
<td>N/C</td>
</tr>
<tr>
<td>8</td>
<td>Analog 8</td>
<td>N/C</td>
</tr>
<tr>
<td>9</td>
<td>Analog 9</td>
<td>N/C</td>
</tr>
<tr>
<td>10</td>
<td>Analog 10</td>
<td>N/C</td>
</tr>
<tr>
<td>11</td>
<td>Parallel Bit 1 (MSB)</td>
<td>N/C</td>
</tr>
<tr>
<td>12</td>
<td>Parallel Bit 2</td>
<td>N/C</td>
</tr>
<tr>
<td>13</td>
<td>Parallel Bit 3</td>
<td>N/C</td>
</tr>
<tr>
<td>14</td>
<td>Parallel Bit 4</td>
<td>N/C</td>
</tr>
<tr>
<td>15</td>
<td>Parallel Bit 5</td>
<td>N/C</td>
</tr>
<tr>
<td>16</td>
<td>Parallel Bit 6</td>
<td>N/C</td>
</tr>
<tr>
<td>17</td>
<td>N/C</td>
<td>N/C</td>
</tr>
<tr>
<td>18</td>
<td>Ground</td>
<td>Tied to Common Ground</td>
</tr>
<tr>
<td>19</td>
<td>Ground</td>
<td>Tied to Common Ground</td>
</tr>
<tr>
<td>20</td>
<td>Parallel Bit 7</td>
<td>N/C</td>
</tr>
<tr>
<td>21</td>
<td>Parallel Bit 8</td>
<td>N/C</td>
</tr>
<tr>
<td>22</td>
<td>Parallel Bit 9</td>
<td>N/C</td>
</tr>
<tr>
<td>23</td>
<td>Parallel Bit 10</td>
<td>N/C</td>
</tr>
<tr>
<td>24</td>
<td>Parallel Bit 11</td>
<td>N/C</td>
</tr>
<tr>
<td>25</td>
<td>Parallel Bit 12</td>
<td>N/C</td>
</tr>
<tr>
<td>26</td>
<td>Parallel Bit 13</td>
<td>N/C</td>
</tr>
<tr>
<td>27</td>
<td>Parallel Bit 14</td>
<td>N/C</td>
</tr>
<tr>
<td>28</td>
<td>Parallel Bit 15</td>
<td>N/C</td>
</tr>
<tr>
<td>29</td>
<td>Parallel Bit 16 (LSB)</td>
<td>N/C</td>
</tr>
<tr>
<td>30</td>
<td>Parallel Read Strobe</td>
<td>N/C</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>Serial Data from Computer (SPS ACRM, VRE, ONS Data)</td>
</tr>
<tr>
<td>33</td>
<td>RS-232 GND (TP2)</td>
<td>Serial Ground</td>
</tr>
<tr>
<td>34</td>
<td>N/C</td>
<td>N/C</td>
</tr>
<tr>
<td>35</td>
<td>N/C</td>
<td>N/C</td>
</tr>
<tr>
<td>36</td>
<td>Ground</td>
<td>Tied to Common Ground</td>
</tr>
<tr>
<td>37</td>
<td>Ground</td>
<td>Tied to Common Ground</td>
</tr>
</tbody>
</table>
8.0 Project Management Plan (PMP)

David Black
Current Team Organization

**Faculty Advisor:**
Dr. Gregory Earle
Dr. Scott Bailey

**Faculty Advisor:**
Dr. Kevin Shinpaugh
kashin@vbi.vt.edu

**Graduate Advisor:**
Robbie Robertson
Juan Ojeda

**Team Leader:**
David Black
dblack10@vt.edu

**ONS Experiment**
Jason Duane
Stephen Mayhugh
Jared Carter
Connor MacNeal

**SPS ACRM Experiment**
Ryan Ligon
Matt Newman
Bas Welsh
Rajesh Kolluri
John Mulvaney
Jeff Brown

**AIS VR Experiment**
Jason Webber
Juan Ojeda
Brian McCarthy
Ryan Hatton
Andrew Bosch

**CAD Team**
Ryan Olmstead
Ryan Hatton
Ryan Ligon
Planned Team Organization for Post-Subsystem Testing

**Faculty Advisor:**
Dr. Gregory Earle  
Dr. Scott Bailey

**Faculty Advisor:**
Dr. Kevin Shinpaugh  
kashin@vbi.vt.edu

**Graduate Advisor:**
Robbie Robertson  
Juan Ojeda

**Team Leader:**
David Black  
dblack10@vt.edu

- **Power Systems Team**
- **Command, Control, and Data Handling Team**
- **Instrumentation Team**
- **Mechanical Team**
Mission Schedule

• NASA Design Review Process:
  – Conceptual Design Review
    • 17 October 2013
  – Preliminary Design Review
    • 8 November 2013
  – Critical Design Review
    • 4 December 2013
  – Delta–Critical Design Review
    • 7 February 2014
  – Subsystem Testing Review
    • TBD 2014
Mission Schedule

• Nominal Team Mission Schedule:
  – All design and CAD work completed
    • 1 January 2014
  – Payload subsystem testing completed
    • 1 March 2014
  – Payload integration and system testing completed
    • 15 April 2014
  – Integration at Wallops
    • June 2014
**Preliminary Budget**

### Overall Breakdown:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
<th>Source</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware and Materials</td>
<td>$3,500.00</td>
<td>VT AOE Department</td>
<td>$7,000.00</td>
</tr>
<tr>
<td>Launch Fee (Full Payload)</td>
<td>$23,000.00</td>
<td>ai solutions</td>
<td>$11,000.00</td>
</tr>
<tr>
<td>Travel</td>
<td>$2,500.00</td>
<td>VSGC</td>
<td>$11,000.00</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$29,000.00</td>
<td></td>
<td>$29,000.00</td>
</tr>
</tbody>
</table>

### Specific Funding Allocations:

| Launch Fee: $23,000.00     | Source: VT AOE Department $4,500.00 | Amount $9,500.00 |
| ai solutions $9,500.00     | VSGC $9,000.00                      | Remainder $-    |
| Travel Costs: $2,500.00    | Source: VT AOE Department $2,500.00 | Amount: Remainder $- |

* Labor/Machining costs are covered by VT AOE Department

** Yellow funds are planned but not fully confirmed.
Team Mentors

• Virginia Tech Faculty
  • Dr. Kevin Shinpaugh
  • Dr. Greg Earle
  • Dr. Scott Bailey

• Virginia Tech Graduate Students
  • Robbie Robertson
  • Juan Ojeda
# Current Team Availability Matrix

**VT RockSat/Virginia Tech:**

Fall 2013 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>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>8:00 AM</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>9:00 AM</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>10:00 AM</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>11:00 AM</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>12:00 PM</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>1:00 PM</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>2:00 PM</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>3:00 PM</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>4:00 PM</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
### Spring 2014 Team Availability Matrix

#### VT RockSat/Virginia Tech:

<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>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>8:00 AM</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>9:00 AM</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>10:00 AM</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>11:00 AM</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>12:00 PM</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>1:00 PM</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>2:00 PM</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>3:00 PM</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>4:00 PM</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
## Team Contact Matrix

### VT RockSat/Virginia Tech:

#### Fall 2013 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>OK to Add to Mailing List?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team Lead</td>
<td>David Black</td>
<td>804-432-2235</td>
<td>804-432-2235</td>
<td>Yes</td>
<td><a href="mailto:dblack10@vt.edu">dblack10@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>UG Member</td>
<td>Ryan Ligon</td>
<td>804-878-2230</td>
<td>804-878-2230</td>
<td>Yes</td>
<td><a href="mailto:rpl42093@vt.edu">rpl42093@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>UG Member</td>
<td>Matt Newman</td>
<td>703-655-1823</td>
<td>702-655-1823</td>
<td>Yes</td>
<td><a href="mailto:mnpnewman@vt.edu">mnpnewman@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>UG Member</td>
<td>Sebastian Walsh</td>
<td>610-368-5539</td>
<td>610-368-5539</td>
<td>Yes</td>
<td><a href="mailto:welshs16@vt.edu">welshs16@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>UG Member</td>
<td>John Mulvaney</td>
<td>859-433-0409</td>
<td>859-433-0409</td>
<td>Yes</td>
<td><a href="mailto:johnwm1@vt.edu">johnwm1@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>UG Member</td>
<td>Jason Webber</td>
<td>804-712-6966</td>
<td>804-712-6966</td>
<td>Yes</td>
<td><a href="mailto:jgwebber@vt.edu">jgwebber@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>UG Member</td>
<td>Brian McCarthy</td>
<td>703-795-8151</td>
<td>703-795-8151</td>
<td>Yes</td>
<td><a href="mailto:bmccar19@vt.edu">bmccar19@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>UG Member</td>
<td>Connor MacNeal</td>
<td>610-717-6290</td>
<td>610-717-6290</td>
<td>Yes</td>
<td><a href="mailto:macnealc@vt.edu">macnealc@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>UG Member</td>
<td>Rajesh Kolluri</td>
<td>703-955-0357</td>
<td>703-955-0357</td>
<td>Yes</td>
<td><a href="mailto:rkolluri@vt.edu">rkolluri@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>UG Member</td>
<td>Stephen Mayhugh</td>
<td>925-963-6653</td>
<td>925-963-6653</td>
<td>Yes</td>
<td><a href="mailto:jmayh8@vt.edu">jmayh8@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>UG Member</td>
<td>Adam Weisz</td>
<td>703-431-8074</td>
<td>703-431-8074</td>
<td>Yes</td>
<td><a href="mailto:adweisz@vt.edu">adweisz@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>UG Member</td>
<td>Seth Austin</td>
<td>540-963-6653</td>
<td>540-963-6653</td>
<td>Yes</td>
<td><a href="mailto:setha07@vt.edu">setha07@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>UG Member</td>
<td>Jared Carter</td>
<td>571-382-8238</td>
<td>571-382-8238</td>
<td>Yes</td>
<td><a href="mailto:jecar102@vt.edu">jecar102@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>UG Member</td>
<td>Jason Duane</td>
<td>703-501-8744</td>
<td>703-501-8744</td>
<td>Yes</td>
<td><a href="mailto:jasond@vt.edu">jasond@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>UG Member</td>
<td>Ryan Olmstead</td>
<td>757-709-3106</td>
<td>757-709-3106</td>
<td>Yes</td>
<td><a href="mailto:ryan8518@vt.edu">ryan8518@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>UG Member</td>
<td>Ryan Hatton</td>
<td>973-479-3295</td>
<td>973-479-3295</td>
<td>Yes</td>
<td><a href="mailto:rhatton@vt.edu">rhatton@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>G Advisor</td>
<td>Adam Weisz</td>
<td>703-431-8074</td>
<td>703-431-8074</td>
<td>Yes</td>
<td><a href="mailto:adweisz@vt.edu">adweisz@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>G Advisor</td>
<td>Juan Ojeda</td>
<td>571-296-1936</td>
<td>571-296-1936</td>
<td>Yes</td>
<td><a href="mailto:juancho2@vt.edu">juancho2@vt.edu</a></td>
<td>U.S. Permanent Resident</td>
<td>Yes</td>
</tr>
</tbody>
</table>

UG = Undergraduate Student  
G = Graduate Student
## Deposit Status

<table>
<thead>
<tr>
<th>Deposit Status:</th>
<th>Funding</th>
<th>Funding Amount</th>
<th>Full Payload:</th>
<th>Covered</th>
<th>Funding Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>VT AOE Department</td>
<td>$</td>
<td>$7,000.00</td>
<td>Earnest Deposit</td>
<td>$</td>
<td>$2,000.00</td>
</tr>
<tr>
<td>ai solutions</td>
<td>$</td>
<td>$11,000.00</td>
<td>First Installment</td>
<td>$</td>
<td>$10,500.00</td>
</tr>
<tr>
<td>VSGC**</td>
<td>$</td>
<td>$11,000.00</td>
<td>Second Installment</td>
<td>$</td>
<td>$10,500.00</td>
</tr>
<tr>
<td>Total:</td>
<td>$</td>
<td>$29,000.00</td>
<td>Total:</td>
<td>$</td>
<td>$23,000.00</td>
</tr>
</tbody>
</table>
Worries/Concerns

- VSGC funding will not be sufficient, leading to a scramble to find funding.
  - Should find out early next week the exact amount the VSGC will be giving us.
This mission will provide successful flight heritage for the SPS aperture cover release mechanism, verifying optimal mechanism design for the LAICE CubeSat mission.

This mission will provide useful data of NO concentration in the upper atmosphere.
- Will also provide more flight heritage for this sensor

Way forward to STR
- Have parts machined.
- Order new ONS photodiode and lens/filter.
- Perform ground tests for each subsystem.
- Begin writing flight software.
- Continue developing detailed electrical schematics
- Order electrical components for the 5 electrical systems.
- Order the electronics deck waterproof housing.
- Determine/order the exact throughput connectors for the electronics deck waterproof housing.
Conclusion

Questions?