RockSat-X @ Virginia Tech
Preliminary Design Review

Virginia Tech
Nick Corbin and Tony DeFilippis
11/15/17
PDR Presentation Content

• Section 1: Mission Overview
  – Mission Statement
  – Mission Objectives
  – Theory and Concepts
  – Concept of Operations
  – Expected Results
  – Minimum Success Criteria
PDR Presentation Content

• Section 2: System Overview
  – Science Design Overview
  – Engineering Design Overview
  – Top Level Requirements
  – Functional Block Diagram
  – Description of Partnerships – with sponsors/collaborators (i.e. NASA or company)
  – User Guide Compliance
  – Special Requests from Rocket/Wallops
PDR Presentation Contents

• Section 3: Subsystem Design
  – Structures
  – Power
  – Science
  – Command and Data Handling
  – Software
  – Other

• Include drawings/pictures of design with dimensions, schematics, pictures of hardware, etc.
PDR Presentation Contents

• Section 4: Risk Matrices

• Section 5: Initial Test Plan
PDR Presentation Contents

• Section 6: Project Management Plan (PMP)
  – Schedule
  – Budget (Labor, launch fee, travel, hardware, etc)
  – Mentors (faculty, industry)
  – Latest Availability Matrix
  – Latest Team Contact Matrix
  – Status of deposit
  – Worries
  – Conclusions
1.0 Mission Overview

Anthony DeFilippis
Mission Overview: Mission Statement

Mission Statement:

- Support STEM education and outreach through utilizing ThinSat platform that can be added to by high schools/universities in order to obtain in situ measurements during space flight

Supply a deployable electronics and communications stack to schools that can then pick various sensors and build the support/circuitry or select them and have us integrate them into the payload.

Open to all levels of engineering experience, show space science to high schools, engage students in STEM
Mission Overview: Mission Objectives

Successfully develop a working ThinSat platform based on lab testing
Successfully deploy at least one ThinSat while in flight
Receive at least one packet of information back from a deployed ThinSat
Record video of ThinSat deployment
Mission Overview: Theory and Concepts

Based on a NASA presentation given at the 31st annual Small Satellite Conference, NASA, Virginia Space, and MARS are working together to do ThinSat launches as secondary payloads in the CubeSat form factor. Utilize rapid launches and short lifetimes to educate students before they graduate. By leveraging sounding rocket launches we believe we can perform similar experiments for a lower cost and still in the same timeframe.
Example #1 ConOps

Altitude

- **t = 0 min**
  - G switch triggered
  - All systems on
  - Begin data collection

- **t ≈ 1.3 min**
  - Altitude: 75 km

  - Altitude: 95 km
  - Event A Occurs

- **t ≈ 1.7 min**
  - Altitude: 95 km

- **t ≈ 3 min**
  - Altitude: ≈150 km
  - Apogee

- **t ≈ 4.0 min**
  - Altitude: 95 km

- **t ≈ 4.5 min**
  - Altitude: 75 km

- **t ≈ 5.5 min**
  - Altitude: 52 km
  - End of Orion Burn

- **t ≈ 15 min**
  - Splash Down

- **t ≈ 15 min**
  - Chute Deploys
Timer Events

GSE-1:
• Begin charging deployment circuitry
• Boot-up mother base to ensure it is ready to receive before deployment of ThinSats

Event A/TE-1:
• Deployment of ThinSats following skirt separation
Mission Overview: Expected Results

Ultimately the type of data will be up to what information high school students would like to see, we will start recommending photometers, accelerometers, temperature/pressure sensors.

This data will be collected by deployable ThinSat “sprites” and transmitted back to the rocket to be stored and sent over NASA telemetry.

The types are unknown, but the data rates will be rather low to support multiple sprites on the same mission.
Mission Overview: Success Criteria

Minimum Success Criteria:
– Successfully deploy one ThinSat and record one data reading

Comprehensive Success Criteria:
– Successfully deploy multiple ThinSats and record several different types of data readings throughout the flight
Top Level Requirements:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification Method</th>
<th>Description</th>
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<tbody>
<tr>
<td>ThinSat deployer must consistently and reliably deploy all ThinSats</td>
<td><strong>Demonstration</strong></td>
<td>Deployer will be tested in different orientations and with different mass dummy ThinSats</td>
</tr>
<tr>
<td>ThinSats must be able to power on and collect data</td>
<td><strong>Demonstration</strong></td>
<td>The ThinSats will be integrated and tested with the systems necessary to demonstrate successful boot up and data collection</td>
</tr>
<tr>
<td>ThinSats must be able to transmit data to mother base</td>
<td><strong>Demonstration</strong></td>
<td>ThinSat communications will be tested in different orientations and at different distances</td>
</tr>
<tr>
<td>The system shall survive the vibration and load characteristics prescribed</td>
<td><strong>Test</strong></td>
<td>The system will be subjected to these vibration loads in June during testing week.</td>
</tr>
<tr>
<td>by the RockSat-X program.</td>
<td></td>
<td></td>
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</table>
De-Scopes and Off-Ramps

• If we cannot work with high schools on our schedule, we will develop our own ThinSats to fly

• Considering removing camera element of payload, as it seems other payloads/NASA are doing similar
2.0 System Overview

Anthony DeFilippis
System Overview: Science Design Overview

Payload:

Instruments:

a. ThinSat Deployer
b. ThinSat mother base

Payload will deploy ThinSats, which will transmit measured data back to payload mother base to be stored and possibly transmitted to VT ground station

- ThinSats will fly TBD sensors
  - We have begun sensor selection, and have a rough idea of the capability we will provide to schools
  - Could also lean towards science experiments as well
System Overview: Engineering Design Overview

Structures

- Structure will be designed to protect sensitive electronics from launch and reentry loads
- Deployer will use springs to eject ThinSats
  - i. Heritage nichrome wire and spring assembly

Power

- Payload electronics will be powered by rocket batteries
- ThinSats will require separate batteries

Electronics

- Heritage local data storage with SD card
- Heritage thermal knife circuit
- Potentially heritage telemetry system
Conceptual Diagram
Conceptual Diagram

Various Arrangement of Sensors or Experiment

Payload Section

PWR
Serial Output

VT Bus Section

Arduino MKR100
- PWR
- GND
- Data In/Out

WiFi Transmitter
- PWR
- GND
- Data In/Out

Coin Cell Battery
- PWR OUT
- GND
- Inhibit

Legend
- Data
- Timer Event
- Power
System Overview: Description of Partnerships

• Orbital ATK
  – Provide engineering advice and feedback
  – Biweekly telecons to assess progress and provide guidance as needed
  – Provide access to testing facilities

• Northrup Grumman
  – Exploring partnership
System Overview: Special Requests

• Planning on using spring deployment system
  – Restrictions/requirements?
    • Can design physical inhibit in addition to electronic
  – See video in DropBox

• Plan with other schools to avoid frequency overlap

• Coin cell/ LiPo batteries alright to fly?
  – 3.7V, 1200mAh
## User Guide Compliance: Summary

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<thead>
<tr>
<th>Requirement</th>
<th>Status/Reason (if needed)</th>
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<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&quot;)</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>
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<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>
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<tr>
<td>Using X GSE Line(s)</td>
<td>YES, GSE 1</td>
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<tr>
<td>Using X Non-Redundant PWR Lines (TE-1, TE-2, TE-3)</td>
<td>YES, TE-1</td>
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<tr>
<td>Using X Redundant Power Lines (TE-R)</td>
<td>YES, TE-R</td>
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<tr>
<td>Using &lt; 1 Ah</td>
<td>YES</td>
</tr>
<tr>
<td>Using &lt;= 28 V</td>
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</tr>
<tr>
<td>Using RF (If yes, list frequency and TX Power)</td>
<td>YES, Likely WiFi/UHF ~433MHz</td>
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<tr>
<td>Using deployable?</td>
<td>YES, Spring deployment; see video</td>
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<tr>
<td>Whole team consists of US Persons</td>
<td>YES</td>
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<tr>
<td>Using ITAR and/or Export Controlled hardware</td>
<td>NO</td>
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3.0 Subsystem Design

Anthony DeFilippis
New ThinSat deployer
   a. Uses heritage thermal knife circuit

Weight
   • Weight Estimate around 10lbs
   • Ballast will be added to reach a total of 15lbs

Hardware required
   • 1 deployer mechanism
     • Spring loaded, thermal knife actuated

Currently, the deployer has too much friction and slop
Deployer Prototype
Subsystem Design: Power

• The deployment circuitry and mother base will run off NASA provided power
• Individual ThinSats will have their own power, provided by either coin cells or LiPo batteries
  – Capacity would be small as flight time is short
  – 1.2Ah or less per ThinSat
• ThinSats are electrically inhibited to be powered off until deployment
• Do not have mother base receiver selected and can therefore not have great idea of power consumption
Subsystem Design: Power

• Deployer similar to last year consumed <0.1Ah
• Mother base receiver power draw largely depends on method, whether radio UHF (high power draw) or WiFi (low power draw)
• Working with industry sponsors to resolve this issue
Conceptual Diagram

Arduino MKR1000

Lithium Ion Polymer Battery - 3.7v 1200mAh
Subsystem Design: Science

• We are hoping to provide both a technically achievable and stimulating experience for students
• Possibility of allowing students to design their own experiment given the constraints, and then provide only serial data output as a result
• This requires definition of bus components, which we are working on
• Have contact information for local schools
• Essentially would like to purchase and provide an arduino and power cell to schools, then have them design/pick their own experiments
• We have various sensors already selected, but final decision will be up to them
• Sensors will communicate to the arduino, which will then transmit over to to WiFi dongle to be transmitted to mother base
• Mother base will transmit data over RS232, possibly UHF to VTGS
Subsystem Design: Software

- All software will be built using the Arduino IDE
- Allows common, cross-platform support with plenty of documentation
- Can be worked on with laptops, ideally anything that comes up in the serial monitor can be transmitted to ground
- Inhibits will be performed mechanically/physically, not through software
4.0 Risk Matrices

Nick Corbin
Risk Matrix

RSK.1: Mission objectives aren’t met IF electronics fail in-flight
RSK.2: Mission objectives aren’t met IF deployer fails
RSK.4: STEM outreach objectives aren’t met IF we are unable to work with schools
RSK.3: Mission objectives aren’t met IF communication fails
RSK.5: Mission objectives aren’t met IF schools don’t complete ThinSats on time
5.0 Test/Prototyping Plan

Nick Corbin
Test/Prototyping Plan

1. Test deployer mechanism with dummy ThinSats to ensure consistent and reliable deployment
   Test thermal knife and locking mechanisms

2. Test communications with mock-up data

3. Test sensor data collection

4. Confirm sensors/data logger/Arduino connection by breadboarding the sensors and Arduino and developing software to analyze data

5. Integrate and test subsystems together

6. Vibration test using Orbital ATK facilities

7. Test all payload components after building and vibe testing payload.
6.0 Project Management Plan (PMP)

*Nick Corbin*
Deposit

• Earnest deposit received October 30th
Management: Team Organization

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

Team Sponsors
Virginia Tech SEC
Virginia Tech AOE
VSGC

Team Leaders:
Nicholas Corbin
cnick1@vt.edu
Tony DeFilippis
dtony@vt.edu

Mechanical
Jonathan Green
Ishan Arora
Irith Sharma
Alex Hallberg
Lauren Honey

Electrical
Nick Miller
Taylor Thackaberry
Steve Kim
Management: Team Mentors

Dr. Kevin Shinpaugh
Dr. Jonathan Black
Ben Hekman, Seth Austin, Ryan Ligon, Ethan Ohriner (Orbital ATK mentors)
Mission Budget

RockSat-X 2018 Detailed Budget

<table>
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<th>Mission Expenses</th>
<th>Amount</th>
<th>Still to Pay</th>
<th>Details</th>
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<td>Earnest Deposit</td>
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<td>Launch Fee Installment 1</td>
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**Total Expenses:** $23,200.00
**Balance:** $3,682.22

Project Funding

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<td>AOE Department</td>
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**Total Funding:** $19,517.78
**Expected Balance:** $7,969.14
Management: Team Schedule

NASA Design Review Process:

- Conceptual Design Review
  - 19 October 2017
- Preliminary Design Review
  - 15 November 2017
- Critical Design Review
  - TBD December 2017

Team Mission Schedule:

- All design and CAD work completed
  - 1 January 2018
- Payload subsystem testing completed
  - 1 March 2018
- Payload integration and system testing completed
  - 15 April 2018
- Integration and testing at Wallops
  - June 2018
# PMP: Latest Team Availability Matrix

<table>
<thead>
<tr>
<th>Team Name/School Here: Virginia Tech</th>
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**Fall 2017 RS-X Team Availability Matrix**

**PLEASE USE MOUNTAIN TIME ZONE TIMES**

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<tr>
<th></th>
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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.

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<tr>
<td>Lowest Priority</td>
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## PMP: Latest Contact Matrix

### Fall 2017 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>Co-Team Lead</td>
<td>Anthony DeFilippis</td>
<td>5208205378</td>
<td>5208205378</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>Co-Team Lead</td>
<td>Nick Corbin</td>
<td>7577480492</td>
<td>7577480492</td>
<td>Yes</td>
<td><a href="mailto:cnick1@vt.edu">cnick1@vt.edu</a></td>
<td>U.S.</td>
<td>No</td>
</tr>
<tr>
<td>Computer Team Lead</td>
<td>Nick Miller</td>
<td>571-271-4714</td>
<td>571-271-4714</td>
<td>Yes</td>
<td><a href="mailto:nmiller1@vt.edu">nmiller1@vt.edu</a></td>
<td>U.S.</td>
<td>No</td>
</tr>
<tr>
<td>Computer Team Member</td>
<td>Steve Kim</td>
<td>703-789-1477</td>
<td>703-789-1477</td>
<td>Yes</td>
<td><a href="mailto:steve8@vt.edu">steve8@vt.edu</a></td>
<td>U.S.</td>
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</tr>
<tr>
<td>Computer Team Member</td>
<td>Taylor Thackaberry</td>
<td>5712467236</td>
<td>5712467236</td>
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<td><a href="mailto:tthacks@vt.edu">tthacks@vt.edu</a></td>
<td>U.S.</td>
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</tr>
<tr>
<td>Mechanical Team Lead</td>
<td>Jonathan Green</td>
<td>703 867 5631</td>
<td>703 867 5631</td>
<td>Yes</td>
<td><a href="mailto:jonatg7@vt.edu">jonatg7@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Mechanical Team Member</td>
<td>Iriti Sharma</td>
<td>5404548166</td>
<td>5404548166</td>
<td>Yes</td>
<td><a href="mailto:isharma@vt.edu">isharma@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Mechanical Team Member</td>
<td>Alex Hallberg</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>Mechanical Team Member</td>
<td>Lauren Honey</td>
<td>757-831-6121</td>
<td>757-831-6121</td>
<td>Yes</td>
<td><a href="mailto:lhoney@vt.edu">lhoney@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Mechanical Team Member</td>
<td>Ishan Arora</td>
<td>7036534003</td>
<td>7036534003</td>
<td>Yes</td>
<td><a href="mailto:ishana97@vt.edu">ishana97@vt.edu</a></td>
<td>U.S.</td>
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</tr>
</tbody>
</table>
PMP: Worries

• **Deployer is not currently smooth or reliable**
  – Higher precision and better materials should mitigate

• **Providing the most meaningful experience for students also introduces more dependence on their success, increasing risk for us**
Virginia Tech has a history of successful payloads, and graduates have gone on to find successful careers in the space industry.

Through our continued efforts, we want to not only continue providing great experience for undergraduates, but also increase our community outreach through local high schools.

Next Steps:
- Secure remaining needed funding
- Research different communications options
- Continue prototyping deployment mechanisms