RockSat-X @ Virginia Tech
Conceptual Design Review

Virginia Tech
Seth Austin and John Mulvaney
October 15, 2015
CoDR Presentation Content

• Section 1: Mission Overview
  – Mission Statement
  – Mission Objectives
  – Theory and Concepts
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  – Expected Results

• Section 2: Design Overview
  – Science Design
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  – Functional Block Diagram
  – Payload Layout (sketches)
  – RockSat-X User’s Guide Compliance
CoDR Presentation Content

- Section 3: Management
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  - Schedule
  - Budget
  - Mentors (Faculty, industry)
  - Risks/Worries
  - Contact and Availability Matrices

- Section 4: Conclusions
Mission Overview: Mission Statement

• To demonstrate the compatibility of a software defined radio (SDR) unit on different communication protocols and the survivability of the components on a sounding rocket flight

• We expect to prove the utility of software defined radio for satellites and its compatibility with SGLS and USN protocols

• The Air Force can use this to free up SGLS network by using different communication protocol such as USN

• This technology can increase the interoperability of satellite communications and enable a low cost ($15K) C2 RF transceiver for Class D missions
Mission Overview: Mission Objectives

- Modify an existing software defined radio unit to survive the expected loads of launch and reentry

- Successfully transmit and receive via SGLS and USN protocols between payload and ground station

- Complete detailed testing and launch operations using modular ground station interface (at Space@VT and/or Wallops)

- Provide design recommendations to Orbital ATK CAD team to modify ETTUS design to include RS422 interface

- Demonstrate tracking capability (through doppler shift) of SDR when compared with GPS telemetry
Mission Overview: Theory and Concepts

• Small satellites are becoming more and more prevalent in industry - all need tracking/communication capability

• The government would like to avoid CubeSats overcrowding their communications networks

• Having the ability to switch between networks would allow small satellites to “fit-in” their communication where bandwidth is available
Example #2 ConOps

1. Launch
   Telemetry/GPS begins
   SDR begins
   Transmission (?)
2. Launch to Apogee
   Telemetry/GPS continues
   SDR transmission continues
   (?)
3. Apogee
   Nose cone separation
   Skin separation
   De-spin to TBD rate
   Telemetry/GPS continues
   Transmission between SGLS and USN to ground station
4. Descent
   Telemetry/GPS continues
5. Chute Deploy
   Telemetry/GPS continues
6. Landing
   Telemetry/GPS terminates
   Payloads recovered
Mission Overview: Expected Results

- Successful communication/command of tasks between the spacecraft and ground (potentially an image or other flight data)

- Observation of a doppler shift in a standard waveform signal from which tracking can be compared to GPS
Design Overview: Science Design

• Instrumentation
  – Ground stations will record whether or not they receive signal from payload
    • Mobile ground station at Wallops
    • Virginia Tech ground station
  – Payload will record whether or not it receives signal from ground stations
    • SD card used to store data

• Payload and ground station will record transmit/receive commands and protocol changes
Design Overview: Engineering Design

• Structure
  – Housing protects payload from space environment, reentry, and splashdown
  – Structure will be designed to protect sensitive electronics from launch and reentry loads
  – Possibility of antenna deployment if needed
• Power
  – Electronics will be powered by NASA’s batteries
• Electronics
  – Software defined radio platform - ETTUS
    • Modify to include RS422 interface
  – 5W S-Band power amplifier
  – Data storage with SD card
• Software must be developed to handle data, switch protocols, process transmit/receive commands
Design Overview: Engineering Design

• Subsystem notes
  – No current heritage elements
  – Payload is very technology dependent

• Testing plans
  – Testing with a SGLS/USN compatible ground modem
  – Radiation testing for single event latchup
We currently do not have a functional block diagram as we are unsure of the specific electrical requirements. This will hopefully be provided next week.
Design Overview: RockSat-X User’s Guide Compliance

- Mass estimate - will not exceed constraint
- No expectation of exceeding allotted space
- Possibility of antenna deployment
- Currently unsure of electronics requirements including ADC lines, Async or Parallel, and timer events. Special accommodation not expected
- CG requirement will be met
- RF - will be transmitting and receiving
- All team members US citizens
Management: Team Organization

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

Team Sponsors
Virginia Tech SEC

Team Leaders:
Sebastian Welsh
welshs16@vt.edu
John Mulvaney
Johnwm1@vt.edu

Seniors
Seth Austin
Alex Dixon
Ryan Ligon
Kyle Simmons

Juniors
Ben Gingras
Genevieve Gural
Emma Manchester
Ethan Ohriner
Sean Roberts

Sophomores
Tony DeFilippis

Freshmen
Ishan Arora
Johnny Jaffe
Management: Preliminary Schedule

• NASA Design Review Process:
  – Conceptual Design Review
    • 15 October 2015
  – Preliminary Design Review
    • TBD November 2015
  – Critical Design Review
    • TBD December 2015

• Team Mission Schedule:
  – All design and CAD work completed
    • 1 January 2016
  – Payload subsystem testing completed
    • 1 March 2016
  – Payload integration and system testing completed (including ground station interaction)
    • 15 April 2016
  – Integration at Wallops
    • June 2016
Management: Monetary Budget

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**Current Balance**  - $16,585.80
## Management: Team Contact Matrix

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<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>
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<tr>
<td>Team Lead</td>
<td>Sebastian Welsh</td>
<td>same -&gt;</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>Team Lead</td>
<td>John Mulvaney</td>
<td>same -&gt;</td>
<td>859-443-0409</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>Team Member</td>
<td>Kyle Simmons</td>
<td>same -&gt;</td>
<td>215-779-0772</td>
<td>Yes</td>
<td><a href="mailto:wskyle12@vt.edu">wskyle12@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Team Member</td>
<td>Alex Dixon</td>
<td>same -&gt;</td>
<td>540-327-9017</td>
<td>Yes</td>
<td><a href="mailto:xandixon@vt.edu">xandixon@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Team Member</td>
<td>Ryan Ligon</td>
<td>same -&gt;</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>
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<tr>
<td>Team Member</td>
<td>Seth Austin</td>
<td>same -&gt;</td>
<td>540-447-4474</td>
<td>Yes</td>
<td><a href="mailto:setha07@vt.edu">setha07@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
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<tr>
<td>Team Member</td>
<td>Ben Gingras</td>
<td>same -&gt;</td>
<td>413-575-1085</td>
<td>Yes</td>
<td><a href="mailto:gben@vt.edu">gben@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
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<tr>
<td>Team Member</td>
<td>Greg Scott</td>
<td>same -&gt;</td>
<td>610-357-6624</td>
<td>Yes</td>
<td><a href="mailto:flyers08@vt.edu">flyers08@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
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<tr>
<td>Team Member</td>
<td>Johnny Jaffee</td>
<td>same -&gt;</td>
<td>203-240-7205</td>
<td>Yes</td>
<td><a href="mailto:jjaffee@vt.edu">jjaffee@vt.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
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<tr>
<td>Team Member</td>
<td>Tony DeFilippis</td>
<td>same -&gt;</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>
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<tr>
<td>Team Member</td>
<td>Ethan Ohriner</td>
<td>same -&gt;</td>
<td>703-343-5688</td>
<td>Yes</td>
<td><a href="mailto:ethano95@vt.edu">ethano95@vt.edu</a></td>
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<tr>
<td>Team Member</td>
<td>Genevieve Gural</td>
<td>same -&gt;</td>
<td>703-346-3609</td>
<td>Yes</td>
<td><a href="mailto:ggural@vt.edu">ggural@vt.edu</a></td>
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<tr>
<td>Team Member</td>
<td>Ishan Arora</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td><a href="mailto:ishana97@vt.edu">ishana97@vt.edu</a></td>
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<tr>
<td>Team Member</td>
<td>Emma Manchester</td>
<td>same -&gt;</td>
<td>410-937-9696</td>
<td>Yes</td>
<td><a href="mailto:emmam95@vt.edu">emmam95@vt.edu</a></td>
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<td>Team Member</td>
<td>Sean Roberts</td>
<td>same -&gt;</td>
<td>610-470-4495</td>
<td>Yes</td>
<td><a href="mailto:seanr13@vt.edu">seanr13@vt.edu</a></td>
<td>U.S.</td>
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<tr>
<td>Team Member</td>
<td>Ramy Armanous</td>
<td>same -&gt;</td>
<td>804-484-0400</td>
<td>Yes</td>
<td><a href="mailto:ramya7@vt.edu">ramya7@vt.edu</a></td>
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Management: Team Availability Matrix

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PLEASE USE MOUNTAIN TIME ZONE TIMES
Management: Team Mentors

- Dr. Kevin Shinpaugh
- Dr. Jonathan Black
- Zachary Leffke (Space@VT Ground Station manager)
- Orbital ATK mentors (TBD - regular design reviews)
Risks/Worries:

• Sufficient ruggedization of the COTS electronic components to survive launch loads
• Space@VT has leading experts in SDR, so we should have strong advisement through the design, build, and testing processes, as well as from Orbital ATK
Conclusion

• Significant benefit for the SmallSat industry - enables communication over a reliable network while mitigating the concern of interfering with government operations

• Next Steps:
  – Communicate further with Orbital ATK
  – Determine electrical needs
  – Begin CAD model and component layouts