NNU RockSat-X 2016
Preliminary Design Review

Northwest Nazarene University
Mitch Kamstra, Braden Grim, Jameson Krueger
11/3/15
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
  – OBC
  – Electronics Box
  – Drawer/Boom Assembly
  – Communications/FleX-ADC
  – EPS
  – Other
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

Jameson Krueger, Mitch Kamstra, Braden Grim
Mission Overview: Mission Statement

- The 2016 Northwest Nazarene University RockSat-X team will test flexible sensors in a space environment and return to earth safely. The test will be communicating sensor data via RFID technology while being extended away from the payload and into space. The test will determine the feasibility of use of passive RFID tags as a power and communication source for such sensors, showing the RF power received over a variable distance, and it will prove the robustness of flexible electronics for use in a space environment. The test will be completed by re-sealing the test platform and returning it to earth safely.

- Additionally, the testing of the ASI FleX ADC will be continued in order to further assess the feasibility of flexible electronic circuits in space.
Mission Overview: Mission Objectives

• Successfully deploy and activate passive, flexible RFID tags after rocket skirt separation
• Successfully gather analog data using FleX ADC and compare it to internal ADC of microcontroller
• Capture video of deployed electronics
Mission Overview: Theory and Concepts

• Passive RFID temperature tags should return temperature values once the reader is activated
  – Received power should vary with distance deployed

• Past NNU experiments have worked with flexible electronics developed by ASI
  – RockSat-X 2015 flight ADC was non-functional and requires a retest in order to gain adequate data
Mission Operations

Altitude

- **t ≈ 1.2 min**
  - Altitude: 75 km
  - *Skirt Deployment*

- **t ≈ 0.6 min**
  - Altitude: 60 km
  - *Begin storing RFID data, cameras on*

- **t ≈ 1.3 min**
  - Altitude: 95 km
  - *Deploy Boom*

- **t ≈ 0.6 min**
  - Altitude: 52 km
  - *End of Orion Burn*

- **Apogee**
  - **t ≈ 2.8 min**
  - Altitude: ≈115 km

- **t ≈ 4.0 min**
  - Altitude: 95 km
  - *Bring Boom in*

- **t ≈ 4.5 min**
  - Altitude: 75 km
  - *All systems off*

- **t ≈ 5.5 min**
  - Altitude: 75 km
  - *Chute Deploys*

- **t ≈ 15 min**
  - *Splash Down*

- **t ≈ -3 min**
  - *All systems on*
  - *Begin data collection (inertial measurement unit)*
Mission Overview: Expected Results

- The RFID tags are expected to return temperature values up to a predetermined extended distance from the rocket
  - Power will decrease as distance increases
    - Getting power values is yet to be determined
- The FleX ADC will return digital values that are reasonably accurate when compared to internal microcontroller ADC
Mission Overview: Success Criteria

Minimum Success Criteria:
– Receive at least one temperature value from RFID tag
– Capture video footage of boom deployment
– Gather analog data using FleX ADC
Mission Overview: Success Criteria

• Comprehensive Success Criteria
  – Fully extend boom with attached RFID tag
  – Collect both temperature and TX power via passive RFID tag
    • Measure power variation over deployed distance
  – Capture video of full deployment
  – Collect all analog data using FleX ADC, store it in OBC, and compare with internal ADC of MCU
2.0 System Overview

Mitch Kamstra, Jameson Krueger
System Overview: Science Design Overview

- Controllers
  - MSP430F5529 Launchpad
  - Raspberry Pi A+ (X2)
  - Arduino

- Sensors
  - Raspberry Pi Camera (X2)
  - Inertial Measurement Unit (IMU)
  - ASI FleX ADC
  - Go Pro
  - Arete Pop RFID reader
  - ASI RFID Tag w/ Temp Sensor
System Overview: Science Design Overview

- The master On-Board Computer (OBC) will be a Texas Instruments ultra low-power MSP430f5529 microcontroller placed on the MSP430 Launchpad. The MSP will control multiple sensors and other microcontrollers. The MSP will directly control a ten degrees of freedom Inertial Measurement Unit (IMU) and Flexible Analog to Digital Converter (ADC). The IMU will collect rocket characteristics throughout the flight. The MSP will facilitate the RFID experiment which will be a Raspberry Pi controlling the Arete Pop RFID reader, powering and communicating with the American Semiconductor RFID tag. This experiment will determine attributes of the sensor and reader with distance and environment as variables.
System Overview: Engineering Design Overview

• The payload structure will consist of two main parts: the Deployable and the OBC/FleX experiment.
• The Deployable will be a box with a drawer used to expose the RFID experiment to the harsh space environment and allow for the extension of the boom from within the drawer. The drawer will reseal prior to reentry to safely return the sensors to the clients for further testing. The reseal and containment design used here will be the same as NNU’s RockSat 2015 as it was successful.
• The OBC/FleX experiment will be housed in a single box completely sealed from the harshness of the space environment to ensure the safe return of the data stored from the experiment. The containment design used here will follow the same as NNU’s RockSat 2015 as is was successful.
## Top Level Requirements:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>The deployable boom shall deploy to a height of no more than 12”</td>
<td><strong>Demonstration</strong></td>
<td>Boom will be expanded to full length in the upright position to verify it doesn’t exceed 12”</td>
</tr>
<tr>
<td>The boom shall extend to the full 12” height in less than 5 seconds from a horizontal position.</td>
<td><strong>Analysis</strong></td>
<td>The system’s dynamical characteristics will be derived from SolidWorks, and available torques will yield minimum response time.</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>
System Overview: Description of Partnerships

- **American Semiconductor and Partner**
  - Financial support
  - Electrical design and troubleshoot assistance

- **Arete mobile**
  - RFID reader manufacturer
  - Initiated communication with company
  - Possible Raspberry Pi platform development
    - If not, Android on Pi
System Overview: User’s Guide Compliance

- Rough Order of Magnitude (ROM) weight estimate 15 lbs.
- Estimate on payload dimensions (will it fit in the payload space?) YES
- Deployables/booms? YES
- How many ADC lines? 5 (approx.)
- Asynchronous/Parallel use? Parallel (half)
  - Do you understand the format?
- Power lines and timer events use? 1 GSE, 2 TE
- CG requirement
  - Do you understand the requirement YES
- Are you utilizing high voltage? NO
- Hazardous Procedures? NO
- RF? YES
- Bolt heads on bottom of deck flush mount? YES
- US Persons for whole team? YES
- ITAR?
System Overview: Special Requests

- NNU has no special requests from Wallops at this time
3.0 Subsystem Design

All
Payload
Subsystem Design: Electronics Box

- All dimensions in mm
- Connectors for data/power lines
- ~ 1 kilogram
- 3 piece design
  • (main box, seal, lid)
Subsystem Design: Drawer/Boom Assembly

- All dimensions in mm
  - 144mm when closed

- ~ 4 kilograms

- Hardware required
  - Stepper motor
  - Tape measure assembly
  - ASI RFID tag
  - Arete RFID reader
  - Raspberry Pi/Camera
  - Draw deployment mechanism
Subsystem Design: Communications and Data

- **RFID Reader – Arete Pop**

  - **RCP (Reader Control Protocol)** is an interface protocol between a device driver of a smart phone and an RFID interrogator. RCP is not including physical layer format. ARETE POP is using stereo out and microphone input as physical layer.

  ![Diagram of RFID Reader – Arete Pop](image)

  **Table: Standards and Notes**

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Standard</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>UHF RFID Protocol</td>
<td>ISO18000-6C / EPC C1G2</td>
<td></td>
</tr>
<tr>
<td>RCP Protocol</td>
<td>ISO29173-1</td>
<td>Not including physical layer</td>
</tr>
</tbody>
</table>
# Subsystem Design: Communication and Data

## Specification

### PHYSICAL
- **Dimension (WxLxH)**: 51 x 50 x 15 mm (without plug), 51 x 67.5 x 15 mm (with plug)
- **Weight**: 30g
- **Indication**: Power on LED (Blue), Charging LED (Red), Tagging LED (Blinking Blue)
- **Battery**: 360mAh
- **Continuous Time**: About 2.0 hours
- **Standby Time**: About 17 hours
- **Charging**: Micro USB 5pin
- **Color**: White

### RFID PERFORMANCE
- **RFID Reader Chip**: PHYCHIPS PR9200
- **Air Protocol**: EPCglobal Class 1 Gen 2 (ISO 18000-6C)
- **Interface**: 3.5 mm Stereo Headset, CTIA, TRRS (4 pole), Audio jack
- **Part No. & Operating Frequency**:
  - A100-K: 917.1 ~ 920.3 MHz (Korea Band)
  - A100-U: 917.1 ~ 926.9 MHz (US Band)
  - A100-E: 865.1 ~ 867.9 MHz (EU Band)
  - A100-J: 920.6 ~ 922.2 MHz (Japan Band)
- **OS**: Apple iOS 6.0, Android 2.3.3 above (as of July 1st 2013)
- **Output Power (EIRP)**:
  - 316mW (25dBm) for US, EU and Korea band
  - 200mW (23dBm) for Japan band
- **RFID Read Distance**: Up to 1.0m (depend on tags)
- **Antenna**: Circularly Polarized Antenna
- **RFID Function**: Read, Write, Lock, Kill
Subsystem Design: Communication and Data

• Flexible RFID tag
  – EM Microelectronic EM4325
  – Technical Data available
    • Just received recently, not included yet
Subsystem Design: Communications and Data

• Keep FleX ADC design same as last experiment
  – Power supply from new EPS
• Separate microcontroller (ATMEGA 328p)
  – Almost entirely separate electrically
  – Housed with Raspberry Pi/EPS/Camera
• ADXL Adafruit Accelerometer
  – 200 g’s
Subsystem Design: EPS (Electrical Power System)

• Switching Regulators over Linear Regulators
  – No overheating
• Overcurrent detection using op-amp comparator circuit
• Opto-isolator for converting TE’s to logic
  – Sparkfun opto-isolator breakout
4.0 Risk Matrices

All
### Risk Matrix: (OBC)

<table>
<thead>
<tr>
<th>Consequence</th>
<th>OBC.RSK.1</th>
<th>OBC.RSK.2</th>
<th>OBC.RSK.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>OBC.RSK.1:</td>
<td>Change in OBC master due to programming complexity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OBC.RSK.2:</td>
<td>Failure of EPS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OBC.RSK.3:</td>
<td>Change of OBC due to inability to communicate with external memory storage device</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Risk Matrix: (Deployable and Structure)

DEP.RSK.1: Full test will not be achieved if deployable fails completely
DEP.RSK.2: Data retrieval could be compromised if deployable detaches on launch
DEP.RSK.3: Deployable will fail if tape measure device cannot be manufactured
Risk Matrix: (Communication and Data)

<table>
<thead>
<tr>
<th>Possibility</th>
<th>COMM.RSK.1</th>
<th>COMM.RSK.2</th>
<th>COMM.RSK.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mission Scope will change if RFID is not approved</td>
<td>yellow</td>
<td>red</td>
<td>yellow</td>
</tr>
<tr>
<td>Minimal data will be recovered if RFID fails at long distance deployment</td>
<td>green</td>
<td>red</td>
<td>yellow</td>
</tr>
<tr>
<td>Mission complexity will change if RFID reader cannot be interfaced with Raspberry Pi</td>
<td>green</td>
<td>yellow</td>
<td>red</td>
</tr>
</tbody>
</table>

COMM.RSK.1: Mission Scope will change if RFID is not approved
COMM.RSK.2: Minimal data will be recovered if RFID fails at long distance deployment
COMM.RSK.3: Mission complexity will change if RFID reader cannot be interfaced with Raspberry Pi
Risk Matrix: (EPS)

EPS.RSK.1: Mission will fail if regulators overheat/malfunction
EPS.RSK.2: New system will be required if opto-isolator circuit cannot function at 30V
EPS.RSK.3: New power regulation will be required if switching regulators fail
5.0 Test/Prototyping Plan

Jameson Krueger
## Test/Prototyping Plan

<table>
<thead>
<tr>
<th>Date Accomplished</th>
<th>System to be tested/Designed</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/2/15 – 12/1/15</td>
<td>Refine Mechanical Design</td>
</tr>
<tr>
<td>11/15/15</td>
<td>Begin building EPS</td>
</tr>
<tr>
<td>11/20/15</td>
<td>Test Opto-isolator concept</td>
</tr>
<tr>
<td>11/30/15</td>
<td>Test voltage output of EPS Apply load to system</td>
</tr>
<tr>
<td>Early December</td>
<td>CDR</td>
</tr>
<tr>
<td>12/15/15</td>
<td>Build deployable prototype</td>
</tr>
<tr>
<td>1/1/16</td>
<td>Select RFID interface method</td>
</tr>
<tr>
<td>1/15/16</td>
<td>Return from school break</td>
</tr>
<tr>
<td>2/1/16</td>
<td>Begin manufacture</td>
</tr>
</tbody>
</table>
6.0 Project Management Plan (PMP)

Jameson Krueger
Team Organizational Chart

Advisors:
Dr. Dan Lawrence
Dr. Stephen Parke

Team Leaders:
Braden Grim
Mitch Kamstra
Jameson Krueger

Mechanical Team:
Braden Grim
Jameson Krueger
(Additional Recruitment)

Team Communication:
Jameson Krueger

Electrical Team:
Mitch Kamstra
Caleb Wolf
(Additional Recruitment)
### Approximate Budget

#### NNU RockSAT-X 2016 Team Budget

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Item Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Cost:</strong></td>
<td></td>
<td>$30,310.00</td>
</tr>
<tr>
<td><strong>Shared Deck:</strong></td>
<td>Cost Minus Funding</td>
<td>$0.00</td>
</tr>
<tr>
<td><strong>Hardware:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controller</td>
<td>$50</td>
<td></td>
</tr>
<tr>
<td>Camera(s)</td>
<td>$400</td>
<td></td>
</tr>
<tr>
<td>Electronics</td>
<td>$500</td>
<td></td>
</tr>
<tr>
<td><strong>Travel:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flight BOI-DCA</td>
<td>$650.00</td>
<td></td>
</tr>
<tr>
<td><strong>Materials:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum</td>
<td>$300</td>
<td></td>
</tr>
<tr>
<td>Machine tools</td>
<td>$300</td>
<td></td>
</tr>
<tr>
<td><strong>Other:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>$300</td>
<td></td>
</tr>
<tr>
<td>PCB material</td>
<td>$100</td>
<td></td>
</tr>
<tr>
<td><strong>RockSAT Fees:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deposit</td>
<td>$2,000.00</td>
<td></td>
</tr>
<tr>
<td>Sharing Payload Cost</td>
<td>$14,000.00</td>
<td>$30,310.00</td>
</tr>
<tr>
<td>Single Trip Total</td>
<td></td>
<td>$7,180.00</td>
</tr>
<tr>
<td>Two Trip Total</td>
<td></td>
<td>$14,360.00</td>
</tr>
<tr>
<td><strong>Funding:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISGC (Travel)</td>
<td>$14,360.00</td>
<td></td>
</tr>
<tr>
<td>NNU (Launch/supplies)</td>
<td>$8,450.00</td>
<td></td>
</tr>
<tr>
<td>ASI and Partner (launch)</td>
<td>$7,500.00</td>
<td>$30,310.00</td>
</tr>
</tbody>
</table>

**Total Cost:** $30,310.00

**Shared Deck Cost Minus Funding:** $0.00
Team Mentors

• American Semiconductor
  – Partner Company - more involvement
• Arete Mobile
• Faculty
  – Dr. Dan Lawrence
  – Dr. Stephen Parke
## Team Name/School Here: Northwest Nazarene University

### Fall 2016 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>Advisor</td>
<td>Dan Lawrence</td>
<td>(208) 608-0534</td>
<td>(208) 608-0534</td>
<td>Yes</td>
<td><a href="mailto:mdlawrence@nnu.edu">mdlawrence@nnu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Advisor</td>
<td>Stephen Parke</td>
<td>(208) 697-2318</td>
<td>(208) 697-2318</td>
<td>Yes</td>
<td><a href="mailto:sparke@nnu.edu">sparke@nnu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Team Member</td>
<td>Jameson Krueger</td>
<td>(208) 602-5279</td>
<td>(208) 602-5279</td>
<td>Yes</td>
<td><a href="mailto:jkrueger@nnu.edu">jkrueger@nnu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Team Member</td>
<td>Braden Grim</td>
<td>(208) 899-3897</td>
<td>(208) 899-3897</td>
<td>Yes</td>
<td><a href="mailto:bgrim@nnu.edu">bgrim@nnu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Team Member</td>
<td>Mitch Kamstra</td>
<td>(509) 879-8465</td>
<td>(509) 879-8465</td>
<td>Yes</td>
<td><a href="mailto:mkamstra@nnu.edu">mkamstra@nnu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
</tbody>
</table>
### Team Availability Matrix

**Team Name/School Here: NNU**

**CoDR RS-X Team Availability Matrix**

<table>
<thead>
<tr>
<th>Oct 12-16</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>1</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>8:00 AM</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>9:00 AM</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>10:00 AM</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>11:00 AM</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>12:00 PM</td>
<td>3</td>
<td></td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>1:00 PM</td>
<td>3</td>
<td></td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>2:00 PM</td>
<td>3</td>
<td></td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>3:00 PM</td>
<td>3</td>
<td></td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>4:00 PM</td>
<td>2</td>
<td></td>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>5:00 PM</td>
<td>2</td>
<td></td>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

**PLEASE USE MOUNTAIN TIME ZONE TIMES**
PMP: Worries

• Interface with RFID reader
  – Develop Raspberry Pi interface
  – Possibly select other reader
• RFID approval
PMP: Conclusions

- This mission will prove the usefulness of FleX RFID reader in space
- Next steps for CDR
  - Continue investigating RFID reader
  - Make more decisions concerning deployment and orientation
  - Begin prototyping EPS