RocketSat-10 Subsystem Testing Review

University of Colorado-Boulder
23 May 2014
STR Deliverables

1. Mission Overview
2. Final Design Description
3. Project Management Update
4. Hardware Procurement Status
5. Individual Subsystem Testing Results
6. Completed Power Budget in xls format
7. Completed Pin Assignments in xls format
8. Completed Timer Event matrix in xls format
9. Full System Testing Plan
10. User Guide Compliance
   - Many of these points will be covered under one section
CDR Presentation Outline

• Section 1: Mission Overview
• Section 2: Final Design Overview and Subsystem Testing Results
• Section 3: Integrated Testing Plan
• Section 4: User Guide Compliance
• Section 5: Project Management Plan (PMP)
1.0 Mission Overview
Mission Overview: Mission Statement

The objective of this mission is to generate a sample of an immiscible alloy composed of Aluminum and Indium in nominal ratios to investigate the effect of solidification in microgravity on the microstructure.
Mission Overview: Mission Objectives

- Observe the effects of solidification in microgravity on the microstructure of an immiscible alloy compared to solidification in gravity
Mission Overview: Success Criteria

- **Minimum Success Criteria**
  - Retrieval of Aluminum-Indium sample formed in microgravity
  - Verification of successful process via telemetry data
  - Generation of ground sample for comparison

- **Comprehensive Success Criteria:**
  - Retrieval of Aluminum-Indium sample formed in microgravity
  - Verification of successful process via telemetry data
  - Generation of ground sample for comparison
Mission Overview: Success Criteria

• Verification of Successful Process
  – Temperature verification of heating
  – Temperature verification of cooling
  – Pressure data for venting verification
    • Temperature can be used for flow verification
  – Acceleration data for microgravity environment verification
Mission Overview: Theory and Concepts

• Sample will be a powdered mixture of Aluminum and Indium
  – Total sample volume about 0.5 cm$^3$ (≈2.5 g)
  – Mass ratios will be determined by AFRL
    • (Likely ~20% indium, 80% aluminum)
  – Melting point of aluminum about 660 °C
Mission Overview: Theory and Concepts

• Induction heating of a metal\(^1\)
  – High frequency, alternating magnetic field on electrically conductive material
  – By Faraday’s law, electrical current must be generated in material within magnetic field
  – Eddy currents of electrical field generates resistance, which generates heat
  – Aluminum has comparatively low resistivity, and thus comparably low inductive heating efficiency.
  – Copper will serve as a material to create a closed circuit inside induction heater by carrying current through Al-In bridge inside crucible to ensure heating throughout melting process

\[^1\]
Mission Overview: Theory and Concepts

- Aluminum-Indium system is monotectic (as compared to eutectic)\(^3,7,8\)
  - Monotectics solidify to form a solid and liquid
    - Both different composition than original liquid
    - Liquid begins as Indium suspended in aluminum
    - During cooling/solidification aluminum matrix forms with long, thin rods of liquid indium inside
    - Further cooling causes indium liquid rods to solidify
      - The less gravitational effect, the smaller and more evenly distributed the indium rods will be
  - Critical temperature: point where immiscible liquid aluminum and indium become miscible, for 20% indium around 660°C (Aluminum melting point)
Plan is to use a bimetallic system of approximately 20% indium by mass, leading to a critical point of about 680°C\textsuperscript{10,11}
Mission Overview: Theory and Concepts

http://quest.arc.nasa.gov/space/teachers/microgravity/emat.html
Mission Overview: Theory and Concepts

• Aluminum-Indium system is monotectic (as compared to eutectic)\textsuperscript{3,7,8}
  – Monotectics solidify to form a solid and liquid
    • Both different composition than original liquid
  – Resulting solid (aluminum matrix) and liquid differ from each other and starting liquid. Then second liquid (indium rods) cools to form homogenous solid

\[ L_1 \rightarrow \alpha + L_2 \text{ (monotectic reaction)} \]

• The chemical and crystal structure of an alloy determines its properties\textsuperscript{2,4,7,8}
  – e.g. mechanical strength and corrosion resistance
  – Atomic arrangement forms crystal structure, which is determined as the alloy solidifies
    • Seeking most thermodynamically stable configuration
Mission Overview: Theory and Concepts

• In bimetallic alloys, much of this structure is determined by the interface between different elements (or planes of elemental atoms) as they cool\(^\text{2,8}\)
  – Gravity-induced buoyancy-driven convection affects this interface
    • Causes interface to displace according to gravity’s differing effect on different elements
  – Gravity also causes sedimentation, separating liquid phase metals rapidly unless the mixture is constantly stirred to homogeneity
  – Strength of bimetallic interface in Al-In system is comparatively high, suggesting gravitational interface displacement should be relatively low
Mission Overview: Theory and Concepts

• Prior Metallic Research in Zero Gravity
  – Life and Microgravity SpaceLab\(^9\)
    • In 1996 a 17 day space shuttle launch from Kennedy Space Center carried an Al-In system, of three varying indium proportions. Heated in the European Advanced Gradient Heating Facility (AGHF). According to NASA, “For this mission there was an unprecedented distribution of teams monitoring their experiments around the world, with experiment commanding performed from three sites.” However, no apparent research papers resulted, and NASA has not responded to requests for information.

  – Battelle Labs\(^7\)
    • SPAR II Rocket flight used for zero g environment. Compared ground alloy aluminum-indium system to zero-gravity alloy. Found that zero-g alloy did not form homogeneously. Instead, had center with high aluminum density and outer sphere with high indium density. Highlights the importance of our mixing method.
Science Testing: Critical Point and Control Samples

- Testing is required to find the critical point for our system of 20% In and 80% Al, which is suspected to lie closer to 700°C.
- Once found, 5 samples will be tested to rule out anomalies.
- From there, groups of 5 samples each will be generated at increasing temperatures to see what changes the added thermal energy adds.
- These samples will act as our control for the launch experiment.
Mission Overview: Expected Results

• Not fully homogenous, possibly partially homogenized bimetallic alloy
• Ability to visualize and compare gravitational mixing of sample for ground vs. 0g
• Optical analysis of alloy structure using optical microscope
• Alloy properties such as resistance to corrosion and melting point can be determined as much as possible, as dictated by size and shape of sample recovered
Testing

Summary:

- Currently testing final crucible design. We tested it without firing it and there seems to be too much thermal conductivity
- Saw highest current draw up to this point (0.8 V across 0.05 Ohm, 16 A)
- Could not melt sample in induction heater
- We melted a control sample (17.5% In by mass) with a blowtorch
- 325 mesh Al and In powders seemed to work the best
- All testing data has been recorded up to this point
Mission Overview: Concept of Operations

Prior to Launch:
Monitor and collect data from temperature, pressure, and acceleration sensors

Upon Launch:
Switch to rocket power and maintain sensor data collection

Upon Achieving Microgravity and De-spin:
Start induction heater and melting of sample

Apogee:
Shut down heater and begin cooling of sample via venting of coolant

Spin-up:
Achieve sample solidification prior to this event

Re-entry:
Shut down all payload systems prior to this event
Proposed Concept of Operations

**Altitude**

- **t = 0 min**
  - Switch to rocket power
  - Collect temp, press, and acceleration data

- **t = 2 min, 8 sec**
  - Altitude: 95 km
  - De-spin/Begin Heating

- **t = 3 min, 8 sec**
  - Altitude: ≈115 km
  - Apogee
  - Heater Shut Down/Begin Cooling

- **t = 5 min, 8 sec**
  - Altitude: 95 km
  - Solidification/Spin-up

- **t = 5 min, 32 sec**
  - Altitude: 75 km
  - Safe all components

- **t = 7 min, 50 sec**
  - End of Orion Burn
  - Altitude: 52 km

- **t = 13 min, 51 sec**
  - Splash Down

- **t = 28 sec**
  - End of Orion Burn
  - Altitude: 52 km

- **t = 5 min, 32 sec**
  - Altitude: 75 km
  - Safe all components

- **t = 7 min, 50 sec**
  - Chute Deploys

- **t = 13 min, 51 sec**
  - Splash Down
Concept of Operations

- Mission timer events and dwell times

<table>
<thead>
<tr>
<th>Event</th>
<th>Time On</th>
<th>Dwell</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSE 2</td>
<td>T-180 sec</td>
<td>512 sec</td>
<td>3 minutes before launch. Start on the computer for the experiment and begin recording data</td>
</tr>
<tr>
<td>TE-3</td>
<td>T+128 sec</td>
<td>60 sec</td>
<td>Turn on induction heater and begin heating of sample</td>
</tr>
<tr>
<td>TE-R</td>
<td>T+188 sec</td>
<td>120 sec</td>
<td>Open solenoid valves and release coolant to begin cooling of the sample</td>
</tr>
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</table>
**Mission Time Line**

**46.008/Koehler**

<table>
<thead>
<tr>
<th>Event</th>
<th>Time (sec)</th>
<th>2 sigma Low Altitude (km)</th>
<th>Nominal Altitude (km)</th>
<th>2 sigma High Altitude (km)</th>
<th>Nominal Range (km)</th>
<th>Velocity (m/s)</th>
<th>Nominal Q (psf)</th>
<th>Mach NO.</th>
<th>Flight Elevation (deg)</th>
<th>Event Control</th>
<th>Timer Type</th>
<th>Dwell Time (sec)</th>
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<tbody>
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<td>Terrier Ignition</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>ground fire</td>
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<td>0.0</td>
<td>0.0</td>
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<td>TM</td>
<td>UMFT</td>
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<tr>
<td>UPR: Add more power, signal flag for launch</td>
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<td>0.0</td>
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<td>VT: Boot Flight Computer</td>
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<td>0.0</td>
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<td>Rail Release</td>
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<td>1.5</td>
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<td>Imp. Malemute Ignition</td>
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<td>Imp. Malemute Burnout</td>
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<td>COSGC: Interrupt #1, Cameras Begin</td>
<td>50.0</td>
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<td>Despin 0 Hz</td>
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<td>NNU: Power ON Cameras</td>
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<td>13.7</td>
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<td>IM CDI</td>
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<td>Att Skirt Separation</td>
<td>70.0</td>
<td>72.2</td>
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<td>1237.9</td>
<td>0.6</td>
<td>4.3</td>
<td>76.2</td>
<td>TM</td>
<td>UMFT</td>
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<tr>
<td>UPR: Signal flag for skirt deployment</td>
<td>70.0</td>
<td>72.2</td>
<td>75.2</td>
<td>78.2</td>
<td>15.1</td>
<td>1237.9</td>
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<td>76.2</td>
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<td>UMFT</td>
<td>276</td>
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<td>COSGC: Interrupt #2, motor rotation / DEPLOY Cameras</td>
<td>72.0</td>
<td>74.4</td>
<td>77.6</td>
<td>80.7</td>
<td>15.7</td>
<td>1219.3</td>
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<td>4.3</td>
<td>76.0</td>
<td>TM</td>
<td>UMFT</td>
<td>10</td>
</tr>
<tr>
<td>COSGC: Pwr to 12V reg, Motor Drive Power</td>
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<td>74.4</td>
<td>77.6</td>
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<td>Nosecone Separation</td>
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<td>0.3</td>
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<td>75.8</td>
<td>TM</td>
<td>UMFT</td>
<td>1</td>
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<tr>
<td>ACS1: Roll and pointing align to target 1</td>
<td>75.0</td>
<td>77.8</td>
<td>81.1</td>
<td>84.4</td>
<td>16.0</td>
<td>1191.5</td>
<td>0.2</td>
<td>4.3</td>
<td>75.7</td>
<td>ACS</td>
<td>electronic</td>
<td></td>
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<td>NNU: Power to Motor</td>
<td>80.0</td>
<td>83.1</td>
<td>86.8</td>
<td>90.3</td>
<td>18.2</td>
<td>1145.2</td>
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<td>75.2</td>
<td>TM</td>
<td>UMFT</td>
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<td>300 kFt Upleg</td>
<td>84.3</td>
<td>87.5</td>
<td>91.5</td>
<td>95.3</td>
<td>19.3</td>
<td>1105.6</td>
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<td>74.7</td>
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<td>N/A</td>
<td>N/A</td>
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<td>ACS1: On Target, maintain alignment</td>
<td>103.0</td>
<td>104.6</td>
<td>109.7</td>
<td>114.7</td>
<td>24.6</td>
<td>935.5</td>
<td>0.3</td>
<td>2.9</td>
<td>72.0</td>
<td>ACS</td>
<td>electronic</td>
<td></td>
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<tr>
<td>CUB: Heating OFF, Coolant Starts</td>
<td>180.0</td>
<td>140.5</td>
<td>150.3</td>
<td>160.1</td>
<td>46.1</td>
<td>329.5</td>
<td>0.0</td>
<td>0.8</td>
<td>31.0</td>
<td>TM</td>
<td>UMFT</td>
<td>158</td>
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<td>Apogee</td>
<td>198.2</td>
<td>140.9</td>
<td>152.0</td>
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<tr>
<td>COSGC: Interrupt #3, RETRACT Cameras</td>
<td>290.0</td>
<td>95.8</td>
<td>112.8</td>
<td>129.2</td>
<td>76.7</td>
<td>904.3</td>
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<td>ACS Spin-up</td>
<td>308.0</td>
<td>77.6</td>
<td>95.8</td>
<td>113.4</td>
<td>81.8</td>
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<td>-74.2</td>
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<td>300 kFt Downleg</td>
<td>312.2</td>
<td>73.0</td>
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<td>109.9</td>
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<td>4.2</td>
<td>-74.7</td>
<td>N/A</td>
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<tr>
<td>COSGC: Interrupt #4 Pre-power loss sequence</td>
<td>320.0</td>
<td>63.8</td>
<td>82.8</td>
<td>101.1</td>
<td>85.3</td>
<td>1177.9</td>
<td>0.2</td>
<td>4.3</td>
<td>-75.6</td>
<td>TM</td>
<td>UMFT</td>
<td>10</td>
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<td>UPR: Signal flag 15 second till power OFF</td>
<td>322.0</td>
<td>61.4</td>
<td>80.5</td>
<td>99.0</td>
<td>85.8</td>
<td>1166.4</td>
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<td>4.3</td>
<td>-75.8</td>
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<td>Power to Student Experiments Off</td>
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<td>UMFT</td>
<td>1</td>
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<td>ACS: Begins Pulsed Venting</td>
<td>330.0</td>
<td>51.4</td>
<td>70.9</td>
<td>89.9</td>
<td>88.2</td>
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<td>Ballistic Impact</td>
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<td>-88.5</td>
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<td>101.3</td>
<td>117.9</td>
<td>0.0</td>
<td>-82.5</td>
<td>ACS</td>
<td>electronic</td>
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<tr>
<td>Chute Deploy</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>101.5</td>
<td>106.3</td>
<td>0.0</td>
<td>-84.3</td>
<td>TM</td>
<td>UMFT</td>
<td>1000</td>
</tr>
<tr>
<td>Payload Impact</td>
<td>831.9</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>101.5</td>
<td>9.7</td>
<td>1.2</td>
<td>-90.0</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Event Control:**
- TM: Terrier Mission
- UMFT: UMFT

**Timer Type:**
- IM CDI: Internal Mission Code
- electronic: Electronic

**Dwell Time (sec):**
- N/A: Not Applicable
2.0 Final Design Overview
Final Design Overview

1. Top Level Requirements of Payload
2. Functional Block Diagram
3. Final Payload Layout Design (Structures)
   – Final components (what will they do and how they work)
4. Final Crucible Design (Structures/Science)
   – Final components (what will they do and how they work)
5. Final Schematic/Electrical Design (Electrical)
   – Final components (what will they do and how they work)
6. Final software layout
   – How will data be stored, how will timer events be handled, how will timer events activate payload events, etc
## Top Level Requirements:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>The system shall be capable of melting sample via induction heating within 60 seconds</td>
<td><strong>Analysis</strong> + <strong>Test</strong></td>
<td>Thermodynamic properties analyzed via software. These approximations to be tested with flight hardware.</td>
</tr>
<tr>
<td>The system shall be capable of cooling and solidifying sample via venting of coolant/gas with 120 seconds</td>
<td><strong>Analysis</strong> + <strong>Test</strong></td>
<td>Thermodynamic properties analyzed via software. These approximations to be tested with flight hardware.</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>
2.1 Structural Final Design
Structural: Final Design Payload Layout
Structural: Final Crucible Design
Structural: Cylinder Size and Gasket

Cylinder Size:
- Interior diameter 0.233”
- Exterior diameter 0.241”
- Leaves 0.009” for foil and tolerances
- Provides snug fit ensuring copper contact and minimal motion from vibrations

Gasket:
- Safety factor of greater than 3.6 using 13 ¼-20 bolts
- Dimensions are finalized, laser cutting on Friday
Structural: Supports, Plate, and Housing

Battery Box and Induction Coil Support
- Both manufacture out of acrylic
- Both fit snugly around their respective parts
- Some vibration damping to be achieved using additional gasket material

Mounting Plate and Large Housing
- Materials are ordered
- Design is finalized
- Manufacturing begins next week
- Hole pattern for mounting plate needs to be completed
Structural: Half Inch Plate
Structural: Large Housing/Shell
Structural: Materials List

Scrape Acrylic (here and available)
- Battery housing (finished)
- Coil holder (finished)
- Resonator brace (being designed)
Gasket Rubber (delivered)
- Gasket (laser cut on Friday)
Alumina Silicate Ceramic (delivered)
- First crucible machined
Pyrex (delivered)
- First crucible lid made
Aluminum Plates (delivered)
- Mounting plate (being machined)
- Large housing (ready to be machined)
Structural: Testing Plans

- Verify the gasket is airtight via vacuum chamber
- Provide adjustments to crucible design as needed
- Ensure all bolts fit in their respective mounting points
- Keep pumping out steel inserts for science team
2.2 Electrical Final Design
Electrical: Final Design Points

- Rocket power to 12V and 5V lines
- Arduino powered by 12V regulated line
- Sensors attached to Arduino analog pins
- Digital pin to relay to control resonator
- Inductor connected to battery bank
- Fuse to protect resonator from overload
- Resonator connector to run induction coil
Electrical: Power and Main Board

- 12V and 5V lines regulated from rocket power
- Low draw sensors powered by Arduino 5V line
- Inductor circuit will be powered by battery bank
  - Typical Inductor run time maximizing at 60 sec, 13.8V, 17A
  - For this scenario only 238.33 mAh of capacity is needed
- This circuit will be activated and deactivated by the microcontroller via an electrical relay
Electrical: Electrical Main Board
Electrical: Electrical Main Board
### Electrical: Wallops Power Pins

<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>NNU</td>
</tr>
<tr>
<td>2</td>
<td>Timer Event Redundant (TE-RA)</td>
<td>Activation of Induction Heater</td>
</tr>
<tr>
<td>3</td>
<td>Timer Event Redundant (TE-RB)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Timer Event 1 (TE-1)</td>
<td>NNU</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td>NNU</td>
</tr>
<tr>
<td>6</td>
<td>GND</td>
<td>NNU</td>
</tr>
<tr>
<td>7</td>
<td>GND</td>
<td>NNU</td>
</tr>
<tr>
<td>8</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>GSE 2</td>
<td>Power to Payload (Arduino, various sensors)</td>
</tr>
<tr>
<td>10</td>
<td>Timer Event 2 (TE-2)</td>
<td>NNU</td>
</tr>
<tr>
<td>11</td>
<td>Timer Event 3 (TE-3)</td>
<td>Activation of Air Release</td>
</tr>
<tr>
<td>12</td>
<td>GND</td>
<td>Payload Ground</td>
</tr>
<tr>
<td>13</td>
<td>GND</td>
<td>Resonator Ground</td>
</tr>
<tr>
<td>14</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>GND</td>
<td></td>
</tr>
</tbody>
</table>

- Finalized power pin assignments, no changes since CDR
- Consistent with RocketSat-X User Guide
## Electrical: Wallops Telemetry Pins

<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>Temp data (thermocouple 1)</td>
</tr>
<tr>
<td>2</td>
<td>Analog 2</td>
<td>Temp data (thermocouple 2)</td>
</tr>
<tr>
<td>3</td>
<td>Analog 3</td>
<td>X-axis acceleration data</td>
</tr>
<tr>
<td>4</td>
<td>Analog 4</td>
<td>Y-axis acceleration data</td>
</tr>
<tr>
<td>5</td>
<td>Analog 5</td>
<td>Z-axis acceleration data</td>
</tr>
<tr>
<td>6</td>
<td>Analog 6</td>
<td>Housing pressure data</td>
</tr>
<tr>
<td>7</td>
<td>Analog 7</td>
<td>Photodiode measurement data</td>
</tr>
<tr>
<td>8</td>
<td>Analog 8</td>
<td>Battery Voltage data</td>
</tr>
<tr>
<td>9</td>
<td>Analog 9</td>
<td>Battery Current data</td>
</tr>
<tr>
<td>10</td>
<td>Analog 10</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Parallel Bit 1 (MSB)</td>
<td>Downlink Picture (NNU)</td>
</tr>
<tr>
<td>12</td>
<td>Parallel Bit 2</td>
<td>Downlink Picture (NNU)</td>
</tr>
<tr>
<td>13</td>
<td>Parallel Bit 3</td>
<td>Airfoil Information (NNU)</td>
</tr>
<tr>
<td>14</td>
<td>Parallel Bit 4</td>
<td>Airfoil Information (NNU)</td>
</tr>
<tr>
<td>15</td>
<td>Parallel Bit 5</td>
<td>Status of Mothership Xbee (NNU)</td>
</tr>
<tr>
<td>16</td>
<td>Parallel Bit 6</td>
<td>Status of HackHD (LED Light) (NNU)</td>
</tr>
<tr>
<td>17</td>
<td>N/C</td>
<td>N/C</td>
</tr>
<tr>
<td>18</td>
<td>Ground</td>
<td>Ground (NNU)</td>
</tr>
</tbody>
</table>

- Finalized pin assignments for telemetry
- Ground will receive pressure, temperature, accelerometer, and battery data
- Consistent with the RocketSat-X User Guide
Electrical: Telemetry Pins Continued
## RocketSat 10 - Power Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Component</th>
<th>Voltage (V)</th>
<th>Max Current (A)</th>
<th>Watts</th>
<th>Time On(min)</th>
<th>Ah</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Microcontroller</strong></td>
<td>Arduino</td>
<td>3.0</td>
<td>0.04</td>
<td>0.12</td>
<td>10</td>
<td>0.007</td>
</tr>
<tr>
<td><strong>Sensors</strong></td>
<td>Accelerometer</td>
<td>3.3</td>
<td>0.0004</td>
<td>0.00</td>
<td>10</td>
<td>0.00007</td>
</tr>
<tr>
<td></td>
<td>Thermocouples &amp; Drivers</td>
<td>5.0</td>
<td>0.0003</td>
<td>0.00</td>
<td>10</td>
<td>0.00005</td>
</tr>
<tr>
<td></td>
<td>Pressure Sensor</td>
<td>5.0</td>
<td>0.002</td>
<td>0.01</td>
<td>10</td>
<td>0.0003</td>
</tr>
<tr>
<td></td>
<td>Photoresistor</td>
<td>5.0</td>
<td>0.02</td>
<td>0.10</td>
<td>10</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>Photodiode</td>
<td>5.0</td>
<td>0.02</td>
<td>0.10</td>
<td>10</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>SD Breakout Board</td>
<td>5.0</td>
<td>0.150</td>
<td>0.75</td>
<td>10</td>
<td>0.025</td>
</tr>
<tr>
<td><strong>External Power</strong></td>
<td>Battery Bank</td>
<td>22.2</td>
<td>1.70</td>
<td>37.74</td>
<td>2</td>
<td>0.06</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>1.93</td>
<td>38.82</td>
<td></td>
<td>0.09842</td>
</tr>
</tbody>
</table>

**2014 CDR**
Electrical: Power Control Board (PCB)

- First PCB schematic was ordered Thursday
  - Expected to arrive week of May 26th
- Second PCB revision to be made by the end of the next week
- Testing board’s functionality while fully integrated
  - Microcontroller, sensors, batteries
## Electrical: Components

<table>
<thead>
<tr>
<th>In House</th>
<th>Need to Order/Waiting On</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Thermocouples and Drivers</td>
<td>• Pressure Sensor</td>
</tr>
<tr>
<td>• Photodiodes</td>
<td>• Photoresistor</td>
</tr>
<tr>
<td>• Accelerometer</td>
<td>• Microcontroller (flight version)</td>
</tr>
<tr>
<td>• Microcontroller (for testing)</td>
<td>• High temperature heat shrink (undecided)</td>
</tr>
<tr>
<td>• 5V &amp; 12V converter</td>
<td>• PCB</td>
</tr>
<tr>
<td>• Relays</td>
<td>• SD Card Breakout Board</td>
</tr>
<tr>
<td>• Batteries</td>
<td></td>
</tr>
<tr>
<td>• Resonator</td>
<td></td>
</tr>
<tr>
<td>• Induction Coil</td>
<td></td>
</tr>
</tbody>
</table>
Electrical: Thermal Sensors

- Does not need a reference junction
- First level of verifying melting sample
- Rates from -270°C to 1372°C
- Potential need for additional insulation
  - Braid’s temperature lower than tip
  - Dependent on MatSci testing
Electrical: Pressure Sensor

- New Honeywell Pressure Sensor
  - Old was unamplified and needing additional circuitry
  - Pressure range from 0-1.6 bar
  - Using 3 pins and running off of 5VDC
Electrical: Photodiode/Photoresistor

- Photodiode more difficult to integrate
  - Wide temp range of -40°C to 125°C
  - Large application usage
  - Cosine correction
- Photoresistor is easier to use
  - Increased sensitivity while testing
- EPS has accommodated for both components
- Spectral range of 400-1000 nm
- Additional mechanism to verify melting of sample
Electrical: Moving Forward

- Bread boarding all sensors to verify the use of components
- Testing PCB and making second revisions by the beginning of week, 6/2
- Fully integrating system with battery configuration
- Verify telemetry connections through GSE testing
- Order remaining hardware
2.3 Software Final Design
Software: Testing Done So Far

- Tested Arduino with following components
  - Electrical relay
  - Thermocouples and drivers
  - Accelerometer (needs to be calibrated)
  - Photodiode
  - SD shield
Software: Electrical Relay

- Requires more than 5V to activate
- Mosfet transistor to turn on and off
- Pulling voltage from the 12V regulator
Software: Thermocouples and Drivers

- Work with amplifier
- Easy to implement into the code
- Movement in test setup
Software: Accelerometer

- Works will with code
- Gives back actual acceleration values
- Just needs to be calibrated/fine tuned
Software: Photodiode/Linear Optical Array

- It works but it is overkill by a factor of 128
- Increases code complexity
- Recommend that we not use it
- Simple photodiode produces the same results
Software: SD Shield

- Interfaced with Arduino and has worked successfully
Software: Testing Plan

- Test pressure sensor when it comes in
- Compile all of the test code together
- Breadboard entire circuit
- Test everything at once
- Once PCB arrives, test it with all sensors
3.0 Integrated Testing Plan
Electrical Testing

- Fully integrating sensors, power shield, and microcontroller to verify all components mimic breadboard tests [end of week 6/2]
- Verify inductor circuit is able to run off of external power source and can fully function with specified timer events [end of week 6/2]
- Confirm telemetry connections with GSE testing - one of the last EPS tests [week of 6/9]
- No component will run off voltage greater than 14V
- No inhibits are used on this payload
Testing Plan: Software Level Testing

- Compile entirety of code and test for success
- With Electrical, test fully integrated electrical system with sensors with Arduino microcontroller with full code
- With Electrical, test/simulate all rocket power lines with code and payload
- Tests to be performed by June 6th
- No software inhibits used/needed
Testing Plan: System Level Testing

- Will integrate subsystem testing plans
- Conduct full subsystem tests before integration tests
  - Subsystem testing will continue, but full integration will not occur till subsystems are confident
- Conduct vacuum chamber tests with full system to ensure pressure seal and system success in vacuum
  - Conduct DITL testing outside of vacuum chamber
  - Move to DITL in vacuum
- Full integration tests to begin during week of June 2nd
4.0 User Guide Compliance
## System Overview: User’s Guide Compliance

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Status/Reason (if needed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center of gravity in 1” plane of plate?</td>
<td>YES</td>
</tr>
<tr>
<td>Weight 15.0 +/- 0.5 lbs?</td>
<td>YES</td>
</tr>
<tr>
<td>Max Height &lt; 5.35”</td>
<td>YES: &lt; 5”</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</td>
</tr>
<tr>
<td>Using &lt; 10 A/D Lines</td>
<td>TBD</td>
</tr>
<tr>
<td>Using/Understand Parallel Lines</td>
<td>N/A</td>
</tr>
<tr>
<td>Using/Understanding Asynchronous Line</td>
<td>YES, at 19200 Baud</td>
</tr>
<tr>
<td>Using X GSE Line</td>
<td>YES, GSE 2</td>
</tr>
<tr>
<td>Using X Non-Redundant PWR Lines</td>
<td>YES, TE-3</td>
</tr>
<tr>
<td>Using X Redundant Power Lines</td>
<td>YES, TE-RA</td>
</tr>
<tr>
<td>Using &lt; 0.5 Ah</td>
<td>YES</td>
</tr>
<tr>
<td>Using &lt;= 28 V (High Voltage)</td>
<td>YES</td>
</tr>
<tr>
<td>Using RF</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>
5.0 Project Management Plan (PMP)
Summer Team Organization Chart

PM: Kristian Kates
SE: Tyler Joy

Advisors
Kamron Medina

STRUCTURES
Andrew Atkinson
Ashley Zimmerer
Jason West
Brandon Boiko

ELECTRICAL
Jannine Vela
Alec Weiss
Lucas Reed
Jon Quinn
Flor Gordivas

COMP SCI
Russell Gleason
Adam Heaton

MATERIALS
Daniel Athey
April Olson
Alex Bertman
## Major Milestone Schedule

<table>
<thead>
<tr>
<th>Event Title</th>
<th>Date of Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual Design Review</td>
<td>21 February 2014</td>
</tr>
<tr>
<td>Preliminary Design Review</td>
<td>07 March 2014</td>
</tr>
<tr>
<td>Critical Design Review</td>
<td>02 May 2014</td>
</tr>
<tr>
<td>Subsystem Testing Review</td>
<td>23 May 2014</td>
</tr>
<tr>
<td>Integrated Subsystem Testing Review</td>
<td>04 June 2014</td>
</tr>
<tr>
<td>Day In The Life (DITL) Testing</td>
<td>23 – 29 June 2014</td>
</tr>
<tr>
<td>Launch Readiness Review</td>
<td>22 July 2014</td>
</tr>
<tr>
<td>Final Integration</td>
<td>05 – 11 August 2014</td>
</tr>
<tr>
<td>Launch</td>
<td>12 August 2014</td>
</tr>
</tbody>
</table>
Preliminary Burn Down Schedule

• May
  – Construction and testing of subsystems

• June
  – Integration of subsystems in into payload
  – Testing of full payload (preliminary DITL)
  – Integration testing at Wallops (June 23rd)
    • Have payload structure built
    • Have electronic system built
    • Have command and data handling built
Preliminary Burn Down Schedule

- July
  - Payload testing and refinement
- August
  - Re-vibe testing if needed (August 5th)
  - Launch of payload (August 12th)
Team Mentors

- Jeff Ganley
  - AFRL Representative
- Arup Maji
  - AFRL Representative
- Chris Koehler
  - Colorado Space Grant Director
  - RocketSat-X Program Manager
# PMP: Latest Contact Matrix

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
<th>Email</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kristian Kates</td>
<td>Project Manager</td>
<td><a href="mailto:krka9002@colorado.edu">krka9002@colorado.edu</a></td>
<td>815-762-7644</td>
</tr>
<tr>
<td>Tyler Joy</td>
<td>Systems Engineer</td>
<td><a href="mailto:tyler.joy@colorado.edu">tyler.joy@colorado.edu</a></td>
<td>808-346-0433</td>
</tr>
<tr>
<td>Daniel Athey</td>
<td>Materials Science</td>
<td><a href="mailto:daniel.g.athey@gmail.com">daniel.g.athey@gmail.com</a></td>
<td>719-243-8258</td>
</tr>
<tr>
<td>April Olson</td>
<td>Material Sciences</td>
<td><a href="mailto:apol5820@colorado.edu">apol5820@colorado.edu</a></td>
<td>970-988-6960</td>
</tr>
<tr>
<td>Alex Bertman</td>
<td>Material Sciences</td>
<td><a href="mailto:alex.bertman@colorado.edu">alex.bertman@colorado.edu</a></td>
<td>303-945-1450</td>
</tr>
<tr>
<td>Jannine Vela</td>
<td>Electrical</td>
<td><a href="mailto:jannine.vela@colorado.edu">jannine.vela@colorado.edu</a></td>
<td>720-448-4416</td>
</tr>
<tr>
<td>Alec Weiss</td>
<td>Electrical</td>
<td><a href="mailto:alwe5353@colorado.edu">alwe5353@colorado.edu</a></td>
<td>303-898-5066</td>
</tr>
<tr>
<td>Lucas Reed</td>
<td>Electrical</td>
<td><a href="mailto:lucas.reed@colorado.edu">lucas.reed@colorado.edu</a></td>
<td></td>
</tr>
<tr>
<td>Jon Quinn</td>
<td>Electrical</td>
<td><a href="mailto:jonathan.quinn@colorado.edu">jonathan.quinn@colorado.edu</a></td>
<td></td>
</tr>
<tr>
<td>Flor Gordivas</td>
<td>Electrical</td>
<td><a href="mailto:flor.gordivas@colorado.edu">flor.gordivas@colorado.edu</a></td>
<td></td>
</tr>
<tr>
<td>Russell Gleason</td>
<td>Software</td>
<td><a href="mailto:rugl1082@coloradoe.du">rugl1082@coloradoe.du</a></td>
<td>425-281-0805</td>
</tr>
<tr>
<td>Adam Heaton</td>
<td>Software</td>
<td><a href="mailto:adhe2495@colorado.edu">adhe2495@colorado.edu</a></td>
<td>802-379-1399</td>
</tr>
<tr>
<td>Andrew Atkinson</td>
<td>Structures</td>
<td><a href="mailto:andrew.atkinson@colorado.edu">andrew.atkinson@colorado.edu</a></td>
<td>206-724-1142</td>
</tr>
<tr>
<td>Ashley Zimmerer</td>
<td>Structures</td>
<td><a href="mailto:aszi3709@colorado.edu">aszi3709@colorado.edu</a></td>
<td>303-378-4901</td>
</tr>
<tr>
<td>Jason West</td>
<td>Structures</td>
<td><a href="mailto:jason.west@colorado.edu">jason.west@colorado.edu</a></td>
<td></td>
</tr>
<tr>
<td>Brandon Boiko</td>
<td>Structures</td>
<td><a href="mailto:brandon.boikos@colorado.edu">brandon.boikos@colorado.edu</a></td>
<td></td>
</tr>
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<td>Kamron Medina</td>
<td>Management</td>
<td><a href="mailto:kamron.medina@colorado.edu">kamron.medina@colorado.edu</a></td>
<td>970-497-9433</td>
</tr>
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</table>
PMP: Design and Payload Concerns

- **Magnetic Field**
  - Induction coil induces current in sample for heating
  - Predicted magnetic field of $\approx 19000$ A/mm inside of coil
  - Magnetic field at distance of 40mm from center 0.3 A/m

- **Coolants**
  - Venting of gas into space surrounding rocket
  - Under pressure in tank ($\approx 75$ psi)

- **Temperature**
  - Expected sample temperature to reach 660°C
  - Induction coil itself may experience heating from current

- **Power**
  - Payload runs on high voltage (12-28 V) and current ($\approx 17$ A)
PMP: Conclusions

• Why does this mission deserve to fly?
  – High feasibility of creating an alloy in a microgravity environment
  – Looking into relatively unexplored field of immiscible alloy crystal structure formation in a microgravity environment
Questions?
Sources of Information and Research


Sources of Information and Research


