RocketSat-10
Critical Design Review

University of Colorado-Boulder
02 May 2014
CDR Presentation Outline

- Section 1: Mission Overview
- Section 2: System Overview
- Section 3: Subsystem Design
- Section 4: Manufacturing Plan
- Section 5: Testing Plan
- Section 6: User Guide Compliance
- Section 7: 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$^3$ ($\approx$2.5 g)
  - Mass ratios will be determined by AFRL
  - Likely 17% indium, 83% aluminum
  - Melting point of aluminum about 660 °C
  - Found a supplier through EPSI Metals
    - Will work with 325 mesh initially
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 a material to create closed circuit inside induction heater by carrying current through Al-In bridge inside crucible to ensure heating throughout melting process
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 17% Indium around 660°C

The miscibility gap in the binary system Al-In has been investigated and the critical temperature and composition estimated as 915°C and 68.8% In, 31.2% Al (by weight). The liquid-liquid partial miscibility region of the ternary system has also been determined. The lowest temperature at which two liquids can exist in equilibrium before a third (solid) phase appears was found to be approximately 500°C. At this temperature, the ternary gap extends to 51.5% Ag, 34.7% Al, and 14.8% In. Isotherms of the ternary gap are given for 50°C intervals between 0°C and 900°C. A true ternary critical point does not exist, i.e., the binary critical temperature is lowered continuously by addition of silver.
Al-In Bimetallic System Critical Point

Plan is to use a bimetallic system of approximately 20% indium by mass, leading to a critical point of about 680°C.
Mission Overview: Theory and Concepts

Aluminum Matrix

Indium Rods
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
  – 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$^{2,4,7,8}$
  – 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\(^2,8\):
  – 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 will also make overcoming surface tension very difficult when mixing
Mission Overview: Theory and Concepts

• Prior Metallic Research in Zero Gravity
  – Life and Microgravity SpaceLab
    • 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
    • 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.
• Testing is required to find the critical point for our system of 17% In and 83% Al, which is suspected to lie closer to 660°C
• Once found, 5 samples will be tested to rule out anomalies
• From there, groups of 5 samples each will be generated at increasing indium masses to see what changes
• 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 versus 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
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

Spin-up: Achieve sample solidification prior to this event

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

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

- **t ≈ 15 min**
  Splash Down

- **t ≈ 2 min**
  Altitude: 95 km
  *De-spin/Begin Heating*

- **t ≈ 5 min**
  Altitude: 95 km
  *Solidification/Spin-up*

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

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

- **t ≈ 6 min**
  Altitude: 75 km
  *Safe all components*

- **t ≈ 5.5 min**
  *Chute Deploys*

- **t ≈ 0 min**
  - Switch to rocket power
  - Collect temp, press, and acceleration data
Concept of Operations

- Proposed 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>600 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+120 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+180 sec</td>
<td>120 sec</td>
<td>Open solenoid valves and release coolant to begin cooling of the sample</td>
</tr>
</tbody>
</table>
2.0 System Overview
Systems Overview: System Changes Since PDR

- PDR/Testing Review Action Items
  - Will we have thin rods of Indium in an Al matrix?
  - Can the crucible be manufactured?
  - Need a more accurate fluid analysis of crucible
  - Ensure safety of pressure vessel
  - Can we run some test of the cooling system?
  - Will sufficient power be provided by the batteries?
  - Can we measure the temperature of the sample?
  - Is the crucible reusable/can it be cleaned effectively?
  - Can a thermocouple be placed on the inside or right outside of the coil?
  - How do we intend to analyze obtained samples?
System Overview: System Changes Since PDR

• Major changes since PDR
  – Switched to copper ring to help with melting
    • Combines resistive and conductive heating
  – Have successfully melted Aluminum with current induction coil/resonator system
## 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>
System Overview: Functional Block Diagram

Wallop's Power & Telemetry

>12 V: Purple
5 V: Yellow
<5V: Green
Induction Energy: Red
Coolant Line: Blue
Analog/Digital Data Lines: Black

Power Control Board

Voltage Regulator

GSE - 2
TE - 3
TE - R

ADC Telemetry Pins (1-10)

Heating System

Batteries

Switch

Power Resonator

Induction Coil

Accelerometer

Pressure

Temperature

Cooling System

Accelerometer

Pressure

Temperature

Coolant Storage

Valve

Crucible/Sample

Arduino Mega

SD Card

Micro-Controller
System Overview: Description of Partnerships

• Air Force Research Laboratory (AFRL)
  – Provide feedback on experimental design
  – Provide feedback on payload design
  – Provides assistance with scientific goals and analysis
  – Works with students to ensure mission criteria are met
De-Scopes and Off-Ramps

• Resistive Heating
  • If the induction system no longer works properly, a simple de-scope will be to directly run current through a metal containment system to melt the sample.
System Overview: Special Requests

• Venting of coolant/gas into vacuum
  – Cooling of sample essential to mission success
  – Current design uses pressure difference between storage and vacuum as driver for the flow of the cooling gas

• Pressurized coolant tank
3.0 Subsystem Design

3.1 Electrical Subsystem
3.2 Structural Subsystem
3.3 Computer Science Subsystem
3.1 Electrical Subsystem
Electrical: Schematic Breakdown

- Rocket power runs to micro-controller
- Sensors attached into analog input pins
- Digital pin to relay to control resonator
- Inductor connected to battery bank
- Fuse to protect resonator from overload
- Resonator connected to run induction coil
Electrical: Power Control Board
Electrical: Battery Board
Electrical: Pressure Board
Electrical: Power

- Will use the rocket’s supplied power to run the microcontroller and sensors
- Inductor circuit will be powered by two Lithium polymer batteries in series
- This circuit will be activated and deactivated by the microcontroller via an electrical relay
Electrical: Inductor Coil

- Plan to use two 11.1 V 850 mAh 3 cell lithium polymer batteries, with a maximum constant discharge rate of 45C, or 38.25 Amps
- Typical Inductor data reports a run time maximizing at 60 second, 13.8 V, and 17 Amps
- For this scenario, only 238.33 mAh of capacity is needed
Electrical: Inductor Circuit Battery

- Turnigy nano-tech 850 mAh 3S Lipo pack
- Listed capacity is actual and not ideal
- Designed for use with high current draw circuitry
## Electrical Subsystem: Power Budget

<table>
<thead>
<tr>
<th>RocketSat 10 - Power Budget</th>
<th>Apr. 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsystem</td>
<td>Voltage (V)</td>
</tr>
<tr>
<td>Arduino</td>
<td>3.0</td>
</tr>
<tr>
<td>Accelerometer</td>
<td>3.3</td>
</tr>
<tr>
<td>Thermocouple &amp; Amp</td>
<td>5.0</td>
</tr>
<tr>
<td>Pressure Sensor</td>
<td>5.0</td>
</tr>
<tr>
<td>Total</td>
<td>0.04</td>
</tr>
</tbody>
</table>
Electrical: Pin Assignments

- Will use a minimum of 5 analog pins with a max of 10

<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></td>
</tr>
<tr>
<td>2</td>
<td>Timer Event Redundant (TE-RA)</td>
<td>Activate cooling system</td>
</tr>
<tr>
<td>3</td>
<td>Timer Event Redundant (TE-RB)</td>
<td>Activate heating system</td>
</tr>
<tr>
<td>4</td>
<td>Timer Event 1 (TE-1)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>GND</td>
<td></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></td>
</tr>
<tr>
<td>11</td>
<td>Timer Event 3 (TE-3)</td>
<td>Activate heating system</td>
</tr>
<tr>
<td>12</td>
<td>GND</td>
<td>Payload Ground</td>
</tr>
<tr>
<td>13</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>GND</td>
<td></td>
</tr>
</tbody>
</table>
EPS.RSK.1: Mission objectives are not met IF batteries are drained before flight
EPS.RSK.2: Mission objectives are not met IF resonator is unable to supply power to induction heater
3.2 Structural Subsystem
Structural: Payload Layout
Structural: Payload Layout

- Battery Box
- Resonator
- Check Valve
- Air Tank
- Solenoid Valve
- Arduino Mega
- Feed through
- Induction Coil
- Crucible
Structural: Aluminum Casing Drawing
Structural: Crucible Design

- Doughnut shaped to maximize coil length
- Secured via 3/8” nylon bolt through center
- Final dimensions still very flexible
- Pyrex lid for photodiode access
Structural: Crucible Design Continued

- Steel heating device for easier packing and sample containment
- 10 gauge wire for copper ring
- Sample flush with Pyrex lid and ceramic bottom
- Steel container design still flexible
Structural: Mass Properties

• Total mass 8.8 lbs currently
• Center of mass
  – \( X = 0.31" \)
  – \( Y = 0.18" \)
• Need to add ballast eventually
Structural: Aluminum Casing

- 4” x 1’ x 1’ block
- Part #P34
- Cost: $350
Structural: Ceramics and Pyrex

• Machinable Ceramic
  – Able to manufacture prototypes in-house
  – Possible looser tolerances
  – McMaster Carr # 8499K627

• 3D Printed Crucible
  – Alumina ceramic (Ceramic stereolithography)
  – Cost: $40 - $200

• Pyrex Lid
  – 1.5” disk with 3/8” hole
  – McMaster Carr # 8477K28
Structural: Check Valve

• 1.4 Atmosphere check valve
• Part #VRV-125-SS-T-20
• Stainless steel
• http://www.generant.com/vrv.shtml#
Structural: Valve Selection

- 1/8” pipe
- 1” Diameter
- 2.5” Height
- 175 psi max
- 12V DC (24V DC and AC also available)
- Submersible
- Use with air, water, and inert gas
- http://www.mcmaster.com/#pneumatic-tanks/=r62qca
Structural: Air Tank Selection

- ¼” ports (need an adaptor for 1/8” pipe)
- 250 psi max
- 16 Cubic inch volume (~2g of air at 90 psi)
- 30F to 250F operation range
Structural: Tubing

- 1/8” Extra-Flexible Nylon Tubing
- Maximum Pressure: 200psi
- Maximum Temperature: 82 Degrees Celsius
- Cost: 25 Feet for $7.50 total
- McMaster Part Number: 5112K41
- Temperature range allows for melting upon reentry to completely vent the tank.
Structural: Gasket Material

- Same as last year
- High Temp resistant Silicone Rubber
  - -60F – 500F
- 1/8” thick
- McMaster #8632K45
Structural: Testing Plan

• Fit check
  – Visual inspection

• Pressure/Seal check
  – Vacuum chamber + Water Test

• Vibration Testing
  – At Wallops
Structural: Risk Analysis

- Check Valve Failure
- Crucible Securement Failure
- Vibe Breaking Induction Heater
- Gasket Failure
- Coolant System Fail
- Possibility
3.3 Computer Science Subsystem
CompSci Subsystem: Software Algorithm

Throughout Launch and Flight:
Monitor Temperature, Acceleration, and Pressure within crucible container and coolant tank

T- 3 Minutes:
Power all systems on
Turn on and monitor sensor data

T+ 2 Minutes:
Power up induction coil
Begin heating and melting

T+ 3 Minutes:
Power down of induction system
Begin cooling and solidification of sample
Involves changing valve state

T+ 6 Minutes:
Power down all subsystems

Pseudo-Code Algorithm

Log the time
Set up logging and storage for sensors
Begin reading sensor data
Begin heating of the metals
Terminate heating of the metals
Begin cooling of metals
Terminate cooling of metals
Terminate logging
System Overview: Software/CDH

- Temperature, Pressure, Acceleration Sensors
- Induction Heater Coil Circuit
- Coolant Control Valves
- Telemetry Data to Wallops FF
- Time Events from Wallops FF
System Overview: Software/CDH
CompSci Subsystem: Software Code

```
#include <SdFat.h>
#include <SdFatUtil.h>

#define error() sd.errorMalt_P(FSTR(e))
#define SD_CHIP_SELECT SS
SdFat sd;

ofstream logfile;
char buf[600];
obufstream bout(buf, sizeof(buf));

float aX, aY, aZ;
float temp1, temp2;
float pressure;

int xpin = A1;
int ypin = A2;
int zpin = A3;
int temp_pin1 = A4, temp_pin2 = A5;
int pressure_pin = A6;
int inductor = 14, solenoid = 16;

int syncTime = 0;
int timer1 = 16, timer2 = 17;
int temp;

void loop(){
  if (!digitalRead(inductor) & digitalRead(timer1))
    digitalWrite(inductor, HIGH);
  if (!digitalRead(inductor) & !digitalRead(timer1)){
    digitalWrite(inductor, LOW);
    digitalWrite(solenoid, HIGH);
  }

  aX = analogRead(A1) * (5.0/1024);
  aY = analogRead(A2) * (5.0/1024);
  aZ = analogRead(A3) * (5.0/1024);
  temp1 = analogRead(temp_pin1) * (5.0/1024);
  temp2 = analogRead(temp_pin2) * (5.0/1024);
  pressure = analogRead(pressure_pin) * (5.0/1024);

  bout << aX << aY << aZ << ',' << temp1 << temp2 << ',' << pressure << endl;

  if (((millis())-syncTime)>2000){
    logfile << buf << flush;
    bout.seekp(0, ios::beg);
    rename(buf, 0, 600);
    syncTime = now;
  }

  if (digitalRead(timer2)){
    logfile << buf << flush;
    logfile.close();
    while(1);
  }
  delay(500);
}

void setup(){
  if (!sd.begin(SD_CHIP_SELECT, SPI_HALF_SPEED))
    sd.initErrorMalt();
  logfile.open("wirescutter");
  if (!logfile.is_open()) error("file.open");
  pinMode(inductor, OUTPUT);
  pinMode(solenoid, OUTPUT);
}
```

```
5.0 Testing Plan
Testing Plan: Mechanical Testing

• Subsystem level requirements
  – Have entire payload be under 15 lbs
  – Survive launch and re-entry conditions

• Tests to be performed
  – Weigh the payload (during construction)
  – Subject payload to vibration testing
    • Will be completed at Wallops FF June 22\textsuperscript{nd}
Testing Plan: Electrical Testing

• Subsystem level requirements
  – Sufficient power to experiment for duration of mission time
  – Sufficient power to sensors and Arduino for duration of mission time

• Tests to be performed
  – Confirm power requirements of system
  – Run system with simulated rocket power and batteries for duration of mission time

• Begin testing by June
Testing Plan: Software Testing

- Subsystem level requirements
  - Command payload to execute experiment
  - Handle incoming data and be able to store it as well as transmit to WFF via telemetry

- Tests to be performed
  - Check code performance on Arduino
  - Ensure inputs properly command payload
  - Ensure data is properly stored/transmitted

- Testing to begin by June
Testing Plan: System Level Testing

• Tests needed to be conducted
  – Experimental/Sample generation
    • Aluminum-Indium system
  – Full DITL testing with all subsystems
  – Vibrational testing for payload integrity

• Testing schedule
  – Experimental/Sample generation ongoing
  – Preliminary DITL testing in June
  – Vibrational testing at WFF June 22\textsuperscript{nd}
6.0 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>
7.0 Project Management Plan (PMP)
Team Organization Chart

PM: Kristian Kates

SE: Tyler Joy

STRUCTURES
Andrew Atkinson
Bryan Watson
Ashley Zimmerer
Noah Remillard

ELECTRICAL
Bryan DiLaura
Jannine Vela
Brett Bender
Alec Weiss

COMP SCI
Russell Gleason
Adam Heaton

MATERIALS
Daniel Athey
Logan Thompson
April Olson
## Preliminary 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>21 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>18 – 23 June 2014</td>
</tr>
<tr>
<td>Launch Readiness Review</td>
<td>22 July 2014</td>
</tr>
</tbody>
</table>
Preliminary Burn Down Schedule

• May
  – Construction and testing of subsystems

• June
  – Integration of subsystems into payload
  – Testing of full payload (preliminary DITL)
  – Integration testing at Wallops (June 22\textsuperscript{nd})
    • 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)
# Monetary Budget

<table>
<thead>
<tr>
<th>Category/Component(s)</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personnel</td>
<td>$15000</td>
</tr>
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<td>Digital Boards and Components</td>
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<td>Coolant Tank, Valves, and Additional Components</td>
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<tr>
<td>Wire, Tubing, Connections</td>
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<tr>
<td>Crucible Material and Manufacturing</td>
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<tr>
<td>Structural Material</td>
<td>$1000</td>
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<tr>
<td>Sample Materials for Experimentation</td>
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<tr>
<td><strong>Total Cost</strong></td>
<td><strong>$48100</strong></td>
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</tbody>
</table>
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>Team</th>
<th>Name</th>
<th>Email</th>
<th>Cell Phone #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Manager</td>
<td>Kristian Kates</td>
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<td>Jon Quinn</td>
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<td></td>
</tr>
</tbody>
</table>
PMP: Design and Payload Concerns

• Magnetic Field
  – Induction coil induces current in sample for heating
  – Predicted magnetic field of \( \approx 19000 \text{A/mm} \) 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\(^\circ\)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
PMP: Conclusions

• **Steps to STR**
  – Refinement of experimental payload
  – Preliminary construction of subsystems
  – Testing of subsystems
    • Structural
    • Electrical
    • Computer Science/CDH
  – Testing will include power and thermal
Sources of Information and Research


   http://quest.arc.nasa.gov/space/teachers/microgravity/emat.html
