New Jersey Space Grant
At Stevens Institute of Technology
Preliminary Design Review

Stevens Institute of Technology
November 1, 2018
In-Situ Reflow Soldering

Scott Maslin, Joshua Gross
Mission Overview

Scott Maslin
Mission Overview: Mission Statement

Create a reflow oven capable of soldering surface mount electronic components to a printed circuit board in the microgravity environment

Minimum Success Criteria
• The oven completes the reflow temperature profile
Mission Overview: Mission Objectives

• Objectives
  – Demonstrate the successful assembly of a printed circuit board in microgravity
  – Identify viability of in-situ electronic manufacturing for space missions

• Project Requirements
  – Develop heating chamber & temperature controller
  – Shall be properly thermally insulated
  – Must be on the axis of rotation (low coriolis)
Mission Overview: Theory and Concepts

- **Reflow Soldering Overview**
  - Electrical & mechanical connections between components and PCB
  - Apply solder to board
  - Place components on top
  - Apply hot air to melt solder and make connections
  - Surface tension aligns components
Mission Overview: Theory and Concepts

Sample Reflow Soldering Profile

- **Ramp to Soak**: 1 - 3°C/SEC
- **Preheat/Soak**: 150°C +/- 20°C, 60 - 120 SECONDS
- **Ramp to Peak**: 1-3°C/SEC
- **Reflow**
- **Cooling**: 2 - 4°C/SEC

Temperature vs. Time Graph

217°C Liquidus
45 - 75 SECS
Mission Overview: Theory and Concepts

- **Hand Soldering Investigations aboard ISS**
- **Reduced-Gravity Flight Experiments**
- **Soldering in Reduced Gravity Experiment (ISS)**
- Hand soldering only
- Focus on quality
- Joints exhibit greater rates of defects
Mission Overview: Expected Results

• Reflow oven completes the reflow profile
• Components achieve permanent mechanical & electrical connection to the PCB without defects
• Same performance as terrestrial process
• Retrieve assembled board
• Process applicable on future space vehicles
Concept of Operations

Altitude

Ramp to reflow temperature
$t \approx 1.3\ \text{min}$

Apogee
Solder Reflow for approx 60 s during freefall
$t \approx 2.8\ \text{min}$
Altitude: $\approx 115\ \text{km}$

End of Orion Burn
$t \approx 0.6\ \text{min}$
Altitude: $52\ \text{km}$

Cooldown & Power Off
$t \approx 4.0\ \text{min}$
Altitude: $95\ \text{km}$

Chute Deploys
$t \approx 5.5\ \text{min}$

Splash Down
$t \approx 15\ \text{min}$

Early Activation
Begin pre-heat
$t = -2\ \text{min}$

RockSat-C 2019
PDR
Success Criteria

• **Minimum Success Criteria:**
  – Measure temperature data within the chamber
  – Heat the chamber with the correct temperature profile for reflow

• **Comprehensive Success Criteria:**
  – Fully soldered set of components upon touchdown
Design Overview

Joshua Gross
# Functional & Design Requirements:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>The box shall heat to 217 °C in an actively controlled manner and cool down to ambient temperature.</td>
<td><strong>Demonstration</strong></td>
<td>Ceramic heaters will heat a confined space containing components, and when the experiment is completed heat sinks shall reduce temperature in the container.</td>
</tr>
<tr>
<td>The system shall heat up to maximum heat by the 3 minute mark mid-mission.</td>
<td><strong>Analysis</strong></td>
<td>The ceramic heaters will follow a typical soldering reflow profile, detailed further on slide 12.</td>
</tr>
<tr>
<td>The full system shall be centered in the canister.</td>
<td><strong>Inspection</strong></td>
<td>The system shall be placed in the center of the canister and verified with rulers and modeling.</td>
</tr>
<tr>
<td>The system shall survive the vibration characteristics prescribed by the RockSat-C program.</td>
<td><strong>Test</strong></td>
<td>The system will be subjected to these vibration loads in June during testing week.</td>
</tr>
<tr>
<td>The full system shall weight within the range of 19.8 to 20.2 lbs.</td>
<td><strong>Inspection</strong></td>
<td>The system shall be put on a scale to determine weight.</td>
</tr>
</tbody>
</table>
De-Scopes & Off-Ramps

• If the desired temperature profile is unable to be achieved in time/budget, a lower temperature profile may be attempted
  • Demonstrate viability of oven system without soldering operation
  • Lower power, insulation requirements
System Overview

Joshua Gross
System Definitions

- **Subsystems**
  - RO: Reflow Oven
  - PS: Power System
Design Overview

• Major components
  – Reflow oven
    • Insulated metal chamber
    • Heating element
    • Temperature sensor (feedback)
    • Temperature controller
      – Minimize schedule/development risk with existing COTS system
  • Test PCB & components
  – Power system
    • Peak power consumption: see analysis
System Design – Physical Model

Beagle bone

Reflow Oven
Design Overview: Ports

• No ports required
## User Guide Compliance: Summary

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<td>Battery Type</td>
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Subsystem Design
Reflow Oven

Scott Maslin
Reflow Oven: Design Overview

- Insulated heating chamber with test PCB inside
- Heated with ceramic heaters
- Reflow controller actively controls heating element via PID
- Temperature feedback via thermocouple
- Mechanical support for parts before soldering
Controller Selection: Trade Study

- Reflow Controller selection underway
- Broad range of choices
- Unique requirements:
  - Size, power, time limited
  - Battery operation instead of mains power
- Will likely need to select an open source microcontroller based controller
  - Modify source code & hardware to adjust for the unique requirements
  - A number of arduino-based options on the market
Reflow Oven: Risks

Risks:
RO.RSK.1: System overheats IF thermocouple, controller fails
RO.RSK.2: System fails to heat up IF ceramic heaters, controller fails
RO.RSK.3: Mission objective will not be achieved IF electronic components to be soldered are not mechanically supported during launch

Risk Mitigation
RO.RSK.1: Thermocouple redundancy, controller fails to heaters off
RO.RSK.2: Controller redundancy, heavy software testing, hardware integration review
RO.RSK.3: Perform extensive shake/drop tests of the support mechanism
Reflow Oven: Analysis

- Produced MATLAB script to analyze heating / energy requirements
- Assumed max 15 g of circuit board & parts
- Requirement driven by temperature profile rates (°C / s)
- Concluded 60 W heat input will be acceptable for the profile
Reflow Oven: Code

- Used MatLab to calculate power needed to heat system (~ 60W)
  - First calculated energy required to heat circuit board from $T_{atm}$ to desired temp
  - Then calculated heat flow (J/s) required to reach desired temp in (x) seconds
  - Finally, calculated oven temp needed to reach appropriate heat flow

```matlab
A = 0.002; % cross-sectional area of the board/oven m^2
L_air = 0.02; % distance between the heater and the board m
L_heater = 0.005; % length/depth of the heater m %
h_air = 10; % convective heat transfer coefficent of air W/(m^2*K) (5 - 50)
k_air = 4.0399e-2; % conductive heat transfer coefficient of air W/(m*K) (2.624e-2 - 4.0399e-2)
k_heater = 18; % conductive heat transfer coefficient of heater W/(m*K)

% How hot does the element need to be?
% Heater term divided by 2 becuase the heat transfers from the center of % the heating element
% air is in 2 locatations so multiplied by 2
T_oven = Q_dot*(L_heater/(2*k_heater*A) + 2/(h_air*A) + L_air/(k_air*A)) + T_pcb; % max temp of the heater needed K
```
Risks and Worries

• Power draw from integrated bus & power consumption
  – Better understanding of energy requirements since CoDR
• Movement of components during flight
• Heating/Insulation requirements
• Discussions ongoing with mechanical engineers to minimise technical risk
Conclusion

• Will demonstrate reflow soldering process in microgravity
• Controller & heater selection and oven mechanical design underway
• Discussions of power requirements ongoing with integration team to synergise requirements
• TBD before CDR
• Questions/issues
Pressure Sensor

Chris Blackwood, Chris Cowan
Mission Overview

*Chris Cowan*
Mission Overview: Mission Statement

The goal of this project is to measure High-Speed Boundary Layer Transitions from laminar to turbulent pressure waves using a high-frequency pressure sensor mounted in a custom port-pocket window that allows the sensor to sit flush with the outer skin of the rocket. The project will be of interest to the research of aerodynamic phenomena in high-speed vehicles.

*This is a repeat project - design has been altered.*
Mission Overview: **Theory and Concepts**

- **High Velocity Boundary Layer Transition**
  - Laminar $\rightarrow$ Unstable $\rightarrow$ Turbulent
  - Measure transition using a static pressure sensor perpendicular to the airflow

- **Laminar to Turbulent transition in High Velocity Boundary layers** helps to predict and control properties such as:
  - Heat transfer
  - Skin friction
Mission Overview: **Theory and Concepts (cont.)**

- Sensor location crucial → pressure is higher near “neck” of rocket than at the center of the shock wave near the tip
  - Transition phase more predominant near this location
Mission Overview: Mission Objectives

- Objectives
  - Measure and record pressure data along surface of launch vehicle using a high frequency pressure sensor.
  - Compile the data produced in real time and write to a file to be analyzed after recovery.
  - Initiate data collection at launch to correlate pressure data to rocket position.

- Goals
  - Characterize the transition phases of the boundary layer through various pressures/velocities along the surface of the vehicle.
Mission Overview: Previous Research

- Considerable prior research has been conducted on Boundary Layer Transitions → Costly data capture methods
  - High speed wind tunnels, military aircraft/rockets
  - Gathering real-world data is valuable
    - Furthers understanding of BL Transitions → increase vehicle performance
    - Determine methods for improving cost effectiveness

- For this project, primary sources of research included:
  - Boundary Layer Transition in High-Speed flows due to roughness
    - Prahladh S. Iyer, Suman Muppidi & Krishnan Mahesh
  - Flight Data for Boundary-Layer Transition at Hypersonic and Supersonic Speeds
    - Steven P. Schneider
  - Development of Hypersonic Quiet Tunnels
    - Steven P. Schneider
  - 2016, 2017, 2018 Stevens RockSAT-C Experiment
Mission Overview: **System Requirements**

1. The pressure sensor shall be exposed to the atmosphere flush with the skin of the launch vehicle - ideally towards the top
   a. A window space will be required to facilitate this

2. Data shall be recorded prior to and during the period of interest
   a. Period of interest is when the rocket is approaching Mach 4
   b. Ideally, data will be recorded beginning just prior to launch, through at least 130-200 seconds of flight

3. Mission requires useable, high-fidelity data to be available upon rocket recovery
   a. Current goals for sample rate and resolution are 1-2 MHz and 16-bits, respectively
   b. Must write file during data collection with minimal loss
Mission Overview: **Expected Results**

- **Minimum Success Criteria**
  - Successfully sample dynamic surface flow at *a minimum of 25% the targeted sample rate* and with *at least 8-bit resolution* within the window of interest.

- Expect to measure instability waves using the pressure fluctuations on the boundary layer of the launch vehicle at the given resolution and sampling rate.
  - Further research can be conducted with both data collected and NASA’s own post flight data.
Mission Overview: Expected Results (cont.)

- Boundary Layer Transitions:
  - The static pressure will reflect the transition of the boundary layer
  - When in the Laminar phase (subsonic), there will be little change in static measurement → utilize Piezoresistive
  - At Mach 1 there should be a sudden increase in static pressure followed by little to mild consistent fluctuations on the order of $10^1$ kPa (supersonic Laminar)
  - Once the flow is fully Turbulent there will be considerable fluctuations in the static pressure on the order of $10^{2-3}$ kPa → utilize the Piezoelectric
ConOps

Altitude

Pressure sensor data capture end
\( t \approx 2.5 \text{ min} \)
Altitude: \(~100 \text{ km}\)

End of Orion Burn – Spin Rate Largest
\( t \approx 0.6 \text{ min} \)
Altitude: 52 km

Apogee
\( t \approx 2.8 \text{ min} \)
Altitude: \(~115 \text{ km}\)

High Tumble Rate
\( t \approx 4.0 \text{ min} \)
Altitude: 95 km

Low N2, Low spin
\( t \approx 5.5 \text{ min} \)
Chute Deploys

\( t = 0 \text{ min} \)

-G switch triggered
-All systems on
-BEGIN recording pressure data

\( T = -3\text{ min} \)
Power on hardware

\( t \approx 15 \text{ min} \)
Splash Down

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Success Criteria

• Minimum Success Criteria:
  – 2 MHz sampling rate with PRUDAQ, 1 MHz cutoff frequency on Low Pass Filter
  – Gain of 30 dB with FIXED gain Op-Amp circuit

• Comprehensive Success Criteria:
  – 5 MHz sampling rate, 2.3 MHz Low Pass Filter
  – Data storage for 3 minutes
  – Automatic Gain Control can vary gain by about +/- 10 dB in response to different input amplitudes
Mission Overview: **Functional Requirements**

- **FUNC.REQ.1:** Accurate and precise collection of data from pressure sensors.

- **FUNC.REQ.2:** Functional watertight pressure sensor mounting design to minimize any noise in pressure readings.

- **FUNC.REQ.3:** Ensure protocol for storage system that can store data for required window and convert A to D in real time.
System Overview

Chris
System Overview: **System Definitions**

**Structures (STR)**

- Sensor Mounting - Port
- Cable and Elec. Component Management
System Level Block Diagram

- Sensor mounted to window and flush with exterior of launch vehicle. Requires airtight seal formed with silicone.
- Wires run from canister, into SMA connectors to specialized window mount.
- Plate mounted to bottom of canister on standoffs. Sensitive equipment mounted with vibration dampeners directly to plate.

Diagram:
- Signal Conditioner
  - Filter
  - Amplifier
- PRUDAQ/Beaglebone
- ADC
- USB Flash Drive
- PSU
- Sensor 1

Text:

- Sensor mounted to window and flush with exterior of launch vehicle. Requires airtight seal formed with silicone.
- Wires run from canister, into SMA connectors to specialized window mount.
- Plate mounted to bottom of canister on standoffs. Sensitive equipment mounted with vibration dampeners directly to plate.
System Overview: Physical Model

Port Pocket

Port Window (2 Sensor Mounting Holes)

Dual SMA Connectors
## System Overview: Ports and Logistics

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Subsystem Design
Structural System (STR)

Chris Cowan
STR: Design Requirements

• Overview
  – Creation of pressure sensor mounting block to connect to Window Pocket → milling of sensor hole in Window
  – Ensures flush mounting of sensors for accurate reading

• Design Requirements
  – STR.REQ.1: The pressure sensors must be mounted flush with the skin of the rocket with an appropriate sized opening
  – STR.REQ.2: The window of the rocket must be pierced and must be airtight to conform to design requirements and prevent water from entering the modules on landing
  – STR.REQ.3: Proper mounts for the sensors are required to be designed and machined (threaded).
STR: Risks

Expected Risks:
- STR.RSK.1: Waterproofing failure
- STR.RSK.2: Measurement objectives fails due to vibrations and shock created by supersonic flight.
- STR.RSK.3: Over mass or size limit

Mitigation:
- STR.RSK.1: Lower error tolerance in sensor piercing other parts
- STR.RSK.2: Reduce vibrations and chance of shortages/detachments
- STR.RSK.3: Develop CAD models and conduct multiple prototype tests
Test/Prototyping Plan

Chris Blackwood
Prototyping Plan

• Test the existing subsystem setup from last year to verify what points of failure existed
  – Looking into mounting on larger rocket and performing mock experiment to imitate similar flight conditions

• Analyze spatial relations in Solidworks
  – Placed in higher priority than the past year. In previous years, very little consideration for board mounting was given

• Prototype plastic tool to check sensor alignment

• Coordinate with other groups to configure canister layout
Prototyping Plan Cont.

**Testing**
- Risk/Concern: Processor will not collect data at an appropriate rate
- Action: Test various setups/DAQs under simulated flight conditions

**Analysis**
- Risk/Concern: Data filter filters out necessary data of flight rather than noise
- Action: Analyze data during and after testing to verify proper filtering

**Mounting**
- Risk/Concern: Need secure mounting system to ensure stable positioning during flight and eliminate possible wiring issues
- Action: Prototype multiple mounting systems including the mounting method and material
Risks & Worries

- Data collection occurs too early in flight
- Faulty wiring/mounting
- Signal attenuation or clipping
- Data overload on system
- Fatigue failure in mechanical or electrical systems
- Inadequate Sampling Rate
- Key Team Members are very busy with Senior Design
Risks and Worries (cont’d)
Conclusion

• Mission:
  – Collect high frequency pressure measurements to analyze the quality of boundary layer flow on the skin of the rocket

• Issues (from last year):
  – Last year, our computer got fried from improper mounting
  – Additionally, two things did not work last year:
    • Automatic Gain Control Circuit
    • Inadequate Sampling Rate

• Plans for action:
  – Do better job planning mounting, creating special mounting brackets
  – Refine software to optimize sampling rate
  – Reverse Polarity-protection diodes!
Accelerometers

Andrew Afflitto, Zachary Shoop
Mission Overview

*Andrew Afflitto*
Mission Overview: **Mission Statement**

- Create a system that can record accelerometer data occurring in a payload during launch to build a model of the rockets telemetry.
- The system will be inexpensive and will consist of commodity hardware in a small footprint.
Mission Overview: **Mission Objectives**

- **Objectives**
  - Implement a simpler iteration of last years design
  - Develop a system for calculating the telemetry of the rocket path in flight using accelerometer data
  - Collect high frequency accelerometer data for use in calculating telemetry

- **Project Requirements**
  - Develop a recording mechanism for reading in-flight acceleration data at high rates
  - Develop a mechanical subsystem for dampening vibration to test against undamped data.
Success Criteria

• **Minimum Success Criteria:**
  – Record data from two accelerometer units
  – Have a model which can be used to compare the data against the given telemetry

• **Comprehensive Success Criteria:**
  – Have data from all accelerometers used and be able to map comparative paths
Mission Overview: **Theory and Concepts**

- Vibration will be measured at high (20 kHz) rates from three-axis accelerometers
  - Can use pairs of two-axis accelerometers to measure all three axes
- One accelerometer will be used as a control
- A second will have passive material to provide some filtering (Neoprene)
Mission Overview: **Theory and Concepts (continued)**

- After data is captured, an analysis will be run to try to approximate telemetry data
  - Plan to use a Kalman filter to estimate position over time
- Computationally expensive, but can be run on a more powerful system than the LPC chip
ConOps - Vibration Isolation

Altitude

- **T = -3 min**
  - Power on hardware
  - G switch triggered
  - G switch position recorded in dataset

- **T = 0 min**
  - Apogee
  - $t \approx 2.8$ min
  - Altitude: $\approx 115$ km

- **T = -1 min**
  - Start data collection

- **$t = 0.6$ min**
  - End of Orion Burn – Spin Rate Largest
  - Altitude: 52 km

- **$t = 2.8$ min**
  - Apogee
  - Altitude: $\approx 115$ km

- **$t = 4.0$ min**
  - High Tumble Rate
  - Altitude: 95 km

- **$t = 5.5$ min**
  - Low N2, Low spin
  - Chute Deploys

- **$t = 6.5$ min**
  - Stop data collection

- **$t = 15$ min**
  - Splash Down

RockSat-C 2019

PDR
Mission Overview: **Expected Results**

- Be able to compare results recorded from onboard electronics (SD card)
- Use data to reconstruct rough rocket trajectory - compare with radar data
- Difference in accelerometer #1 and #2 from passive material
# Functional Requirements

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<td>The data will be sampled at a rate of 44 kHz and be recorded on an SD (or micro SD) card(s).</td>
<td>Analysis</td>
<td>The system will sample at the Nyquist frequency required to obtain clear readings from all channels from all accelerometers.</td>
</tr>
<tr>
<td>The code will run off of a microcontroller.</td>
<td>Demonstration</td>
<td>The gathering/processing code will run without an OS present (to minimize delay) and without human input.</td>
</tr>
<tr>
<td>The passive materials will be mounted without causing interference to other systems.</td>
<td>Test</td>
<td>Passive materials will be aligned together, and positioned so that they will not interfere with the active system or electronics.</td>
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<tr>
<td>Electronics will be managed and integrated in a neat and orderly manner.</td>
<td>Inspection</td>
<td>Mounting, electronics connections and cable management will be done efficiently to save space and make internal components easy to access and modify.</td>
</tr>
<tr>
<td>The data will be able to model the telemetry of the rocket in flight</td>
<td>Analysis</td>
<td>The model will be able to chart a basic test telemetry obtained from a vibration table.</td>
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De-Scopes & Off-Ramps

- If three-axis accelerometer systems are not tenable, then two-axis accelerometer systems will be used instead
  - Can reuse last year’s accelerometer boards
System Overview

Zachary Shoop
Subsystem Design Section: **Electrical**

- Accelerometer #1
- Accelerometer #2
- LPCXPresso 43S67
- SD Card Subsystem
- Power Management Subsystem

Connections:
- G-switch Signal
- 5V
Subsystem Design Section: Structural

Vibrations → Neoprene → Electronics
Vibrations → Control
Subsystem Design Section: Component Selection

- Most of the components are already bought and ready to use from previous year
- Neoprene was selected for its availability and its vibration isolative properties
  - Risk of structural failure
- SD Card Reading Subsystem
  - Need to design a mount for the SD Card
System Design – Physical Model

- Beagle bone
- Reflow Oven
- Behind
- LPC Chip
- Accelerometer 1
- Accelerometer 2
Ports

- Accelerometer Team is not using Ports
## RockSat-C 2018 User's Guide Compliance

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SDA: Risks

● Expected Risks:
  - SDA.RSK.1: Mission objectives are not met if microcontroller begins recording when it shouldn’t
  - SDA.RSK.2: Wiring/other physical issues interrupt data collection

● Possible fixes
  - SDA.RSK.1: Implement redundant timed start on data processing/control program
  - SDA.RSK.2: Maintain proper electronics and cable management throughout development process
STR: Risks

- **Expected Risks:**
  - STR.RSK.1: Nuts unscrew due to vibrations
  - STR.RSK.2: Electronics with voltage on the can
  - STR.RSK.3: Failure of Mechanical Backbone

- **Possible fixes**
  - STR.RSK1: Use nylon nuts and locktight
  - STR.RSK.2: put electrical tape on all electronics
  - STR.RSK.3: Vibration testing
Risks and Worries

- Reading and writing from SD card directly from LPC board
- SPI communication with accelerometers
Conclusion

● Semi-new innovative design
  ○ Simplified from last year
  ○ Need to determine if we should find new 3 axis sensors

● SD Card Writing implementation needs to be fully understood for the LPC Chip
  ○ Lack of documentation

● Telemetry post analysis will be executed after data is captured and can be analyzed on more powerful hardware
Subsystem Design
Power System

Jesse Stevenson
Power Management Objectives

- Microcontroller w/ SD card
  - over-current control and logging
- High-side switching instead of low side switching
- Isolation between projects if one fails / shorts
  - Current limiting
  - Separate regulators
Component comparison: Switching

• Methods of switching high-side voltages
  – Relay
  – Solid state relay
  – Dedicated load switch IC
  – Custom MOSFET w/ charge pump circuit
  – 5V Regulator with enable line
• Comparison on next slides
• No trade study table, instead advantages, disadvantages
Component comparison: Switching :::: Relay

• Advantages
  – Easiest to integrate
  – Cheap (comparatively)
  – High current / voltage limit

• Disadvantages
  – Needs back emf protection
  – Susceptible to vibration failures
  – No built in current limiting
  – Large size

• Ask about relays used at Wallops(?)
Component comparison: Switching ::::: Solid State Relay

• Advantages
  – Medium current / voltage limit
  – No vibration problems
  – Low on resistance

• Disadvantages
  – No built in current limiting
Component comparison: Switching :::: Dedicated ICs

• Advantages
  – SPI controllable current limiting
  – Better fault detection (shorts, open loads, etc)
  – Multi-channel outputs - better density, simpler design

• Disadvantages
  – Generally < 1A output current limit
  – Smaller SMD pads - harder to hand solder, repair and prototype
Component comparison: Switching :::: MOSFET - CP

• **Advantages**
  – More flexibility in requirements / limits

• **Disadvantages**
  – Analog circuit design
  – No built in current monitoring
  – More complicated circuit - more to go wrong
Component comparison: Switching :::: Regulator w/ en

• Advantages
  – 5V regulation built into same chip
  – Enable line controllable by 3V logic

• Disadvantages
  – Generally < 1A output current limit
  – No current monitoring built in
  – Usually require additional analog components for tuning
Component comparison: Switching :::: Decision

• Will move forward with relay for high current loads
  – Soldering project heating element

• 5V regulator with enable line for other electronics (if available)
  – Beaglebone and microcontroller powering
  – Over-estimation at 1A
Electrical Block Diagram: 1 of 2

- 5V 1A
- 24V 50mA

- 5V 1A

- 5V 1A

- 5V 1A

- 12V 5A (60W)

12V

Current Shunt

Current Shunt

Current Shunt

Current Shunt

Relay #4

Vibration team electronics

Pressure team electronics

Soldering control/elec

Soldering project heater/cool
Electrical Block Diagram: 2 of 2

Controller

12V

T-3 min
activation

5V reg

power in

5V reg

Control #1
Control #2
Control #3
Control #4

Relay

Power control module (arduino)

sd card logs
Power subsystem risk matrix

- **Expected Risks:**
  - PS.RSK.1: Mission objectives not met if the power subsystem does not boot
  - PS.RSK.2: Mission objectives are not met if power subsystem fails due to an overload
  - PS.RSK.3: Mission objectives are not met if power drops below voltage for some interval

- **Possible fixes**
  - PS.RSK1: Include override jumpers in design to bypass system if not functioning reliably
  - PS.RSK.2: Maintain fast control loop for controller, add capacitors to handle spikes
  - PS.RSK.3: Testing to ensure power requirements of projects match system output
Prototype / Testing plan

• Evaluate feasibility of switching solutions

• Prototypes
  – Test 5V regulators w/ enable lines, especially overload conditions
  – Testing relay prototype in vibration heavy environment for continuity
  – Test Arduino control with current measurement: latency between short and shutdown
Test/Prototyping Plan

Name of Presenter
## Prototyping Section

<table>
<thead>
<tr>
<th>Item</th>
<th>Risk / Concern</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramic Heating Element</td>
<td>Concern about ability to effectively deliver heat to the chamber</td>
<td>Prototype the heater circuit and measure the max temperature / power of the element</td>
</tr>
<tr>
<td>Oven controller interface with heating element</td>
<td>Risk that COTS reflow oven controller will not be able to directly interface with the heaters</td>
<td>Perform trade studies to select controller, verify interface, potentially prototype interface circuit</td>
</tr>
<tr>
<td>Oven Insulation</td>
<td>Risk that excess heat will have adverse effect on the canister / other investigations</td>
<td>Prototype with selected insulation material and measure heat transfer</td>
</tr>
</tbody>
</table>
Combined Project Management Plan

Joshua Gross
Payload Layout:

- Plan to use the midplate
- Mount the electronics boards vertically between projects and power
  - 4 boards (power, accel, soldering, pressure)
- Standardized power / signal connections
  - For any inter-payload communication
  - Activation lines, etc
  - Easier disconnect / connection
  - Looking at D-sub connectors for this
## Schedule Part 1

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Start</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>CoDR Teleconference</td>
<td>Thu 10/08/18</td>
<td>Thu 10/08/18</td>
</tr>
<tr>
<td>Earnest Payment of $1000 Due</td>
<td>Fri 10/12/18</td>
<td>Fri 10/12/18</td>
</tr>
<tr>
<td>MATLab Data Analysis Program</td>
<td>Thu 10/19/18</td>
<td>Thu 10/19/18</td>
</tr>
<tr>
<td>Preliminary Design Review (PDR) Teleconference</td>
<td>Mon 11/1/18</td>
<td>Fri 11/1/18</td>
</tr>
<tr>
<td>Preliminary Cannister Set Up</td>
<td>Sun 11/26/18</td>
<td>Sun 11/26/18</td>
</tr>
<tr>
<td>Prototype Electrical Design</td>
<td>Thu 11/30/18</td>
<td>Thu 11/30/18</td>
</tr>
<tr>
<td>Obtain All Parts</td>
<td>Fri 12/1/18</td>
<td>Fri 12/1/18</td>
</tr>
<tr>
<td>Critical Design Review (CDR) Teleconference</td>
<td>Mon 12/6/18</td>
<td>Fri 12/6/18</td>
</tr>
<tr>
<td>Finalize Mechanical Portion</td>
<td>Mon 12/25/18</td>
<td>Mon 12/25/18</td>
</tr>
<tr>
<td>Electronic Design and Schematic</td>
<td>Thu 12/28/18</td>
<td>Thu 12/28/18</td>
</tr>
<tr>
<td>Final Down Select- Flights Awarded</td>
<td>Wed 1/09/19</td>
<td>Wed 1/09/19</td>
</tr>
<tr>
<td>Progress Update Telecon</td>
<td>Mon 1/21/19</td>
<td>Thu 1/25/19</td>
</tr>
<tr>
<td>Finish Canister Construction</td>
<td>Thu 2/1/19</td>
<td>Thu 2/1/19</td>
</tr>
<tr>
<td>First Payment due</td>
<td>Mon 2/11/19</td>
<td>Mon 2/11/19</td>
</tr>
<tr>
<td>Subsystem Testing Review Teleconference</td>
<td>Mon 2/11/19</td>
<td>Fri 2/15/19</td>
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## Schedule Part 2

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Progress Update Telecon</td>
<td>Mon 3/4/19</td>
<td>Fri 3/8/19</td>
</tr>
<tr>
<td>Integrated Subsystem Testing Review Teleconference</td>
<td>Mon 3/18/19</td>
<td>Fri 3/18/19</td>
</tr>
<tr>
<td>Final Payment due</td>
<td>Mon 4/11/19</td>
<td>Mon 4/11/19</td>
</tr>
<tr>
<td>RockSat Payload Canister sent to customers (pending receipt of final payment)</td>
<td>Mon 4/11/19</td>
<td>Mon 4/11/19</td>
</tr>
<tr>
<td>Progress Update Telecon</td>
<td>Mon 4/15/19</td>
<td>Fri 4/19/19</td>
</tr>
<tr>
<td>Full Mission Simulation Test Report Presentation Telecon</td>
<td>Mon 4/29/19</td>
<td>Fri 5/3/19</td>
</tr>
<tr>
<td>Progress Update Telecon</td>
<td>Mon 5/20/19</td>
<td>Fri 5/24/19</td>
</tr>
<tr>
<td>Possible Program Telecon</td>
<td>Wed 5/29/19</td>
<td>Wed 5/29/19</td>
</tr>
<tr>
<td>Preliminary Check-In Procedure Document Due</td>
<td>Mon 6/3/19</td>
<td>Mon 6/3/19</td>
</tr>
<tr>
<td>Launch Readiness Review Document Due</td>
<td>Mon 6/3/19</td>
<td>Mon 6/3/19</td>
</tr>
<tr>
<td>Travel to Wallops Flight Facility</td>
<td>Wed 6/12/19</td>
<td>Wed 6/12/19</td>
</tr>
<tr>
<td>Visual Inspections at Refuge Inn</td>
<td>Thu 6/13/19</td>
<td>Thu 6/13/19</td>
</tr>
<tr>
<td>Vibration/Integration at Wallops</td>
<td>Fri 6/14/19</td>
<td>Mon 6/17/19</td>
</tr>
<tr>
<td>Presentations to Next Year's RockSat</td>
<td>Wed 6/19/19</td>
<td>Wed 6/29/19</td>
</tr>
<tr>
<td>Launch Day</td>
<td>Thu 6/20/19</td>
<td>Thu 6/20/19</td>
</tr>
<tr>
<td>Preliminary Launch Results Document Due</td>
<td>Fri 7/12/19</td>
<td>Fri 7/12/19</td>
</tr>
<tr>
<td>Final Report Due</td>
<td>Fri 7/26/19</td>
<td>Fri 7/26/19</td>
</tr>
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</table>
# Preliminary Budget

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Cost per Item ($)</th>
<th>Total Cost</th>
<th>Vendor</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLA</td>
<td>3</td>
<td>$24.55</td>
<td>$73.65</td>
<td><a href="http://a.co/1b2lt6T">http://a.co/1b2lt6T</a></td>
</tr>
<tr>
<td>nuts and bolts (approximately)</td>
<td>5</td>
<td>$5.00</td>
<td>$25.00</td>
<td><a href="https://www.home">https://www.home</a> depot.com/p/Plexiglas-24-in-x-48-in-x-0-125-in-Acrylic-Sheet-4-Pack-MC2448125/206855693</td>
</tr>
<tr>
<td>Acrylic Sheet</td>
<td>1</td>
<td>$105.00</td>
<td>$105.00</td>
<td><a href="https://www.theme">https://www.theme</a> talstore.co.uk/products/mild-steel-box-section-5mm</td>
</tr>
<tr>
<td>50mm x 50mm x 5mm Mild Steel Box - 1.5 metre length</td>
<td>1</td>
<td>$27.00</td>
<td>$27.00</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Total:</strong> $348.61</td>
</tr>
</tbody>
</table>
Organization Changes from Last Year

• Objectives
  – Integration - first priority
  – Less separation between projects
  – More productive meetings

• Implementation
  – Students assigned to tasks rather than projects
  – Responsibility on a given task distributed to a task lead
Organization Chart:

- Prof. Joseph Miles
  Faculty Coordinator

- Jesse Stevenson
  Electrical and
  Power Integration
  Lead/Final QA

- Stephen Kontrimas
  Mechanical
  Integration Lead

- Scott Maslin
  Soldering

- Andrew Afflitto
  Vibe Iso 2.0

- Chris Cowan/Blackwood
  Pressure Sensor

- Everyone Else
  People pulled as needed
Task organization - Trello

- Similar to Japanese Kanban
- Columns - indicate state of a task
  - Planning
  - TODO
  - Doing
  - Review
  - Finished
  - Presentation / Documentation
Task organization - Trello

- Project leads create tasks
- A task lead is assigned to each task
  - Responsible for ensuring the completion of the task
  - Groups working on each task define their own meeting times
Task organization - Trello Overview
Task organization - Card Detail

Preliminary thermal calculations for soldering project

Description Edit
Need to know how much power is required to heat the oven to the required temperature profile

Add Comment
Write a comment…

Add to Card
Members
Labels
Checklist
Due Date
Attachment

Activity
Jesse Stevenson Oct 4 at 9:25 PM
@scottmaslin1 is the project lead for the soldering experiment, if you have requirement questions, ask him

Jesse Stevenson Oct 4 at 9:24 PM
@aidanaquino is the lead for this task
Task organization - Goals

- Better work breakdown
- More flexible meeting times
- Better collaboration between projects
- Stress / responsibility more equally shared
  - Presentation contents by task
Team Contact Matrix

Link here: https://docs.google.com/spreadsheets/d/1NkXavvrmnGbBwNCVrNKxBGwIBz2-GtbZ18JVJQ6ZRUG/edit?usp=sharing

Team composition is fluid
Team Availability Matrix

- **Bold indicates Jesse’s availability**

<table>
<thead>
<tr>
<th>Time (MST)</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 pm</td>
<td>10</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>7 pm</td>
<td>13</td>
<td>6</td>
<td>8</td>
<td>11</td>
<td>5</td>
</tr>
</tbody>
</table>
Risks and Worries

• More projects than prior years
  – Project management is very important for success
• One entirely new project to integrate
Conclusion

• Team is excited to get working on the challenges this year poses
• Looking forward to improving from last year and acquiring new data
Risks and Worries

• More projects than prior years
  – Project management is very important for success
    • Having difficulty organizing different levels
• One entirely new project to integrate
Conclusion

• Team needs to dedicate more time
  – May need to restructure the team
  – Will have a hard internal deadline to make better use of time

• Need to catch up on some work for CDR
  – CAD model
  – Software breakdowns
  – Design Custom Circuitry