New Jersey Space Grant at Stevens Institute of Technology
Integrated Subsystem Testing Review

Stevens Institute of Technology
Sponsored by the New Jersey Space Grant
April 3rd, 2018
Presentation Outline

• Section 1: Mission Overview
• Section 2: Design Overview
• Section 3: Subsystem Status
• Section 4: Integrated Subsystem Testing Status
• Section 5: Full System Integration Plan
• Section 6: Project Management Update
Pt. 1 - Vibration Isolation

Andrew Afflitto, Aidan Aquino, Jonathan Covret, Joshua Gross, Stephen Kontrimas, Matthew McGinn George-Douglas Price, Jesse Stevenson, Zachary Shoop, Adam Testa, Sam Yakovlev
1.0 Mission Overview

Adam Testa
Mission Overview: Mission Statement

- Create a system that can record and isolate vibrations occurring in a payload during launch for sensitive electronics and other equipment
- The system will be inexpensive and will consist of commodity hardware in a small footprint
Mission Overview: Mission Objectives

- Objectives
  - Improve on last year’s design
  - Test new system’s effectiveness and create a reusable electrical system for vibration measurement

- Project Requirements
  - Develop a recording mechanism for reading in-flight acceleration data at high rates
  - Test a wider range of passive material
  - Develop mechanical subsystems for dampening vibration
    - For the active system, a set of electronics + microcontroller to react to changes in acceleration
Mission Overview: Theory and Concepts

- Vibration will be measured at high (greater than 40 kHz) Hz rates from two-axis accelerometers
- One accelerometer will be used as a control
- Vibrations will be reduced using either passive or active means
  - Active: Similar to camera stabilization
  - Passive: Three-axis system and material-based absorption
ConOps - Vibration Isolation

Stop data collection / vibration isolation
\( t \approx 1.3 \text{ min} \)
Altitude: 75 km

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

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

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

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

T = -3min
Power on hardware
-G switch triggered
-All systems on
-Begin recording + vibration isolation

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

Splash Down
\( t \approx 15 \text{ min} \)
Mission Overview: **Expected Results**

- Be able to compare results recorded from onboard electronics (SD card)
- Noticeable reduction in jerk (change in acceleration)
  - Better reduction than last year (measured by %)
- Would permit launch of more precise payloads (i.e. mass spectrometers)
Mission Overview: **Success Criteria**

- **Minimum Success Criteria**
  - Data that can be compared with last year

- **Comprehensive Success Criteria**
  - Comparable results between control and isolated vibration recordings
  - Equipment reusable for future launches
  - Better vibration reduction than previous experiment (measured by % difference)
## Functional Requirements:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active System will adjust actuators to mitigate vibration.</td>
<td>Demonstration</td>
<td>The active system will adjust its actuators to better act against vibration, using an algorithm to process current data during acquisition.</td>
</tr>
<tr>
<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>
</tr>
<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>
</tbody>
</table>
Changes since STR

• No changes to Mission Overview
2.0 Design Overview

Stephen Kontrimas and Andrew Afflitto
Canister View
Lower Level Canister View
New Controlled Active Isolator (CAI) Design
System Level Block Diagram
Electrical Design Elements - Breakout Block Diagram

ACCL1 → Notch Filter → A/D Converter → Connector to motherboard

ACCL1 → Notch Filter

RockSat-C 2018

CDR
Electrical Design Elements - Motherboard Block Diagram

ACCL Breakout 1

ACCL Breakout 2

ACCL Breakout 3

ACCL Breakout 4

ACCL Breakout 5

Active Control Daughter Board (TBD)

Beaglebone

G Switch activation

Battery

FET Switch

Volt Regulator

3 min activation
Electrical Design Elements - WIP: Motherboard Circuit
Electrical Design Elements - Accelerometer Breakout
Start → Collect Data

- Control Algorithm (subject to change)
- Drive actuators to counteract
- Determine power to drive actuators to counteract
- Process change since last measurement

- Storage Full?
  - Yes → Stop
  - No → Record Data to Active Isolation Files → Yes
  - No → Record Data to Passive Isolation Files → No

Start

Collect Data

Record Data to Active Isolation Files

Record Data to Passive Isolation Files
Hazardous Mechanical Items

- No hazardous mechanical items
Hazardous Electrical Items

- No hazardous items
Motherboard Schematic
Power Supply Daughter-board Schematic

- Schematic in progress (next slide)
  - Found buck converter for board: LMR16030
  - Provides 6 amps from up to a 30 V supply at ~90% efficiency
- Specification
  - Dual regulator setup - one for vibration isolation project, other for pressure sensor
    - Prevents overcurrent from one project from affecting the other project
  - Contains switching circuitry for T-3 min activation
  - Connectors for battery
Power Supply Daughter-board Schematic (WIP)

Check datasheet (parallel capacitors)
## EPS: Power Budget

<table>
<thead>
<tr>
<th>Component</th>
<th>Voltage (V)</th>
<th>Max Current (A)</th>
<th>Time On (min)</th>
<th>Watts</th>
<th>Wh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beaglebone</td>
<td>5V</td>
<td>500 mA</td>
<td>15 min</td>
<td>2.5 W</td>
<td>0.625 Wh</td>
</tr>
<tr>
<td>ACC Board</td>
<td>5V</td>
<td>180 mA</td>
<td>15 min</td>
<td>0.9 W</td>
<td>0.225 Wh</td>
</tr>
<tr>
<td>Daughterboard</td>
<td>12V</td>
<td>~2A</td>
<td>15 min</td>
<td>~24 W</td>
<td>6 Wh</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Required:</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>27.4 W</strong></td>
<td><strong>6.85 Wh</strong></td>
</tr>
<tr>
<td><strong>Total Power Capacity (6 lipo cell)</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>60 W</strong></td>
<td><strong>18.5 Wh</strong></td>
</tr>
<tr>
<td><strong>Over(+) / Under(-)</strong></td>
<td></td>
<td></td>
<td></td>
<td>+ <strong>32.6 W</strong></td>
<td><strong>11.65 Wh</strong></td>
</tr>
</tbody>
</table>
3.0 Subsystem Status

Stephen Kontrimas
Subsystems Overview

- Electronics and Power Systems (EPS)
- Controlled Active Isolator (CAI)
  - Creating the actuator is independent of EPS
- Magnetic Passive System (MaPS)
- Structures (STR) - Mechanical Integration
Subsystem Testing Status: EPS

- The breakout boards ADC and filter have been tested via SPI
- The Beaglebone system has been coded but as of yet untested
- Still need to solder accelerometers on boards - will be done over the next week (when Bosch lab is open)
Subsystem Testing Status: CAI

- Finished Design
- Waiting on Parts
- Only single axis due to spacing in canister
Subsystem Testing Status: MaPS

MaPS System Works

- Magnets repel as expected and required
- Only missing tests with accelerometer inside
  - No issues expected, testing will be done within next few weeks

- No numbers data to report
Subsystem Testing Status: STR

- Design is all set, and parts are in hand
- Requires some EPS and canister to conduct test
- Parts need to be split up for printing
4.0 Integrated Subsystem Testing Status

Aidan Aquino
Electronics and Power Systems

• Breakout board ADC and Filter Testing
  ○ Waveform signal put on Accelerometer output
  ○ Working ADC and Filter

• Beaglebone receiving testing (Not Tested)
  ○ Attaching above test to beaglebone, reading output there

• Testing with Accelerometers (Not Tested)
  ○ Attach accelerometers and read off values on Beaglebone

• Power and Voltage Regulator (Not Tested)
  ○ Manufacture and test, make sure it can go up to current rating
Controlled Active Isolator (Not Tested)

• Test the motion of the Actuators
  ○ Take readings on the response rate on a given current
  ○ Use this for calibrating control algorithm

• Test Control Algorithm with “Vibration” (shaking)
  ○ Shake the system and compare it to a static environment
  ○ Expect vibrations to be lessened to a static environment
Magnetic Passive System (Not Tested)

- **Test 1 - To Be Performed**
  - MaPS (with accelerometer inside) and bare accelerometer on flat board
  - Vibrate board through some motor action
  - Record both accelerometers with Beaglebone
  - Expected Results: Damped vibration from MaPS
- **Subsequent tests not necessary**
  - More about reading data from multiple channels by that point
Structures (Mechanical Integration) (Not Tested)

• Passive Vibration Isolation Materials Testing
  ○ Use some sort of vibration equipment to measure materials affect on vibration isolation through accelerometers

• Complete Integration
  ○ Assemble all parts of canister and see if they work in tandem and give accurate results
5.0 Plan for Full System Integration

Zachary Shoop
Canister Integration Testing

• Fit test canister
  – w/ canister substitute if necessary
• All components mounted on plates - as long as fits within plate should fit in canister
• Full System Testing
  – Mostly electronics
  – Active sensor (?)
Vibe Test

- Vibe Test
  - Will use vibe test data as a trial run
  - Spare materials already in hand
  - Spare accelerometers and board
  - Can make spare active system
Electrical Testing

• Refer to Electrical and Power Subsystems Testing
• Check for high current draw
• Use ammeter to ensure there isn’t too much battery drain
  – Possibly use equipment with current logging capabilities
Software Testing

- Test the function of the Beaglebone code
- Test its function with the G-switch
- Ensure various methods work
System Level Testing

• Simulate a test launch
  ○ Confirm electronics start up / record

• Test performance dates
  ○ 4/23-4/27
Plan for FMSR

• Plan to stick to schedule:
  ○ Weekly goals
  ○ Stick to schedule
  ○ Consistent communication
  ○ Step-by-step testing

• Major Hurdles:
  ○ Time constraints
  ○ Scheduling conflicts
  ○ End of semester
6.0 Project Management Update

Jesse Stevenson
## Schedule

<table>
<thead>
<tr>
<th>Event</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated Subsystem Testing Review Teleconference</td>
<td>Mon 3/26/18</td>
<td>Fri 3/30/18</td>
</tr>
<tr>
<td>Order Parts and Finalize Active Design</td>
<td>Mon 4/2/18</td>
<td>Mon 4/9/18</td>
</tr>
<tr>
<td>Request/Fabricate housing and foundation parts</td>
<td>Mon 4/9/18</td>
<td>Fri 4/13/18</td>
</tr>
<tr>
<td>RockSat Payload Canister sent to customers (pending receipt of final payment)</td>
<td>Mon 4/9/18</td>
<td>Mon 4/9/18</td>
</tr>
<tr>
<td>Progress Update Telecon</td>
<td>Mon 4/9/18</td>
<td>Fri 4/13/18</td>
</tr>
<tr>
<td>Subsystem Tests / Housing and foundation construction</td>
<td>Mon 4/16/18</td>
<td>Fri 4/20/18</td>
</tr>
<tr>
<td>Complete BeagleBone Black System</td>
<td>Mon 4/16/18</td>
<td>Fri 4/20/18</td>
</tr>
<tr>
<td>Finish Mission Simulation</td>
<td>Mon 4/23/18</td>
<td>Fri 4/27/18</td>
</tr>
<tr>
<td>Full Mission Simulation Test Report Presentation Telecon</td>
<td>Mon 4/30/18</td>
<td>Fri 5/4/18</td>
</tr>
<tr>
<td>Test / Construct Ordered Parts</td>
<td>Mon 5/7/18</td>
<td>Fri 5/11/18</td>
</tr>
<tr>
<td>Progress Update Telecon</td>
<td>Mon 5/21/18</td>
<td>Fri 5/25/18</td>
</tr>
</tbody>
</table>

- The active isolation is behind schedule but close to finalization
Summary of Progress

• Progress on CAI design
  – Voice Coil Design completed
  – Working on ordering parts

• Electronics ADC and Filter
  – Tested using Arduino in “slow” capture

• Code written for Beaglebone
  – Testing in progress
## User Guide Compliance

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Status/Reason (if needed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center of gravity in 1&quot; mid-can?</td>
<td>Do not know yet, but we intend to</td>
</tr>
<tr>
<td>Contained in can</td>
<td>Yes</td>
</tr>
<tr>
<td>Connected to can by 4/5 bulkheads on top and bottom only</td>
<td>Do not know yet, but we intend to</td>
</tr>
<tr>
<td>Mass at 20±0.2lbs</td>
<td>Yes</td>
</tr>
<tr>
<td>Shared canister clearance</td>
<td>Using mid plate and nothing below</td>
</tr>
<tr>
<td>No voltage on the can</td>
<td>Yes</td>
</tr>
<tr>
<td>No voltage on multipurpose port</td>
<td>Not using multipurpose port</td>
</tr>
<tr>
<td>Activation wires at least 4 ft</td>
<td>Do not know yet, but we intend to</td>
</tr>
<tr>
<td>Activation wire at least 24 gauge</td>
<td>Do not know yet, but we intend to</td>
</tr>
<tr>
<td>Early Activation: current &lt; 1 A</td>
<td>Do not know yet, but we intend to</td>
</tr>
<tr>
<td>T-0 Activation: current &lt; .1 A</td>
<td>Do not know yet, but we intend to</td>
</tr>
<tr>
<td>Battery Type</td>
<td>Lithium Polymer (will not charge at Wallops)</td>
</tr>
</tbody>
</table>
Design Overview: Shared Can Logistics

• Hobart and William Smith Colleges’ Goals:
  – 1) Measure muon flux at different levels in the atmosphere.
  – 2) Model Earth's magnetic field with respect to altitude.
  – 3) To get local students involved

• Plan for collaboration
  – Communicate by Email
  – They sent us their inventor model
  – We sent an onshape link to them

• We are using mid plate
Design Overview: Shared Can Logistics

Successfully Imported HWS model into OnShape
## Vibration Isolation Team Planned Operating Budget

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Cost per Item ($)</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLA</td>
<td>3</td>
<td>$24.55</td>
<td>$73.65</td>
</tr>
<tr>
<td>Polymagnets (RING)</td>
<td>6</td>
<td>$11.75</td>
<td>$70.50</td>
</tr>
<tr>
<td>Accelerometer Chip</td>
<td>12</td>
<td>$31.57</td>
<td>$378.84</td>
</tr>
<tr>
<td>Beaglebone black (from Amazon) same as pressure group</td>
<td>1</td>
<td>$58.98</td>
<td>$58.98</td>
</tr>
<tr>
<td>nuts and bolts (approximately)</td>
<td>5</td>
<td>$5.00</td>
<td>$25.00</td>
</tr>
<tr>
<td>Acrylic Sheet</td>
<td>1</td>
<td>$105.00</td>
<td>$105.00</td>
</tr>
<tr>
<td>Accelerometer Breakout board (w/o Accel Chip)</td>
<td>6</td>
<td>$25.00</td>
<td>$150.00</td>
</tr>
<tr>
<td>MicroSD Card (2-pack)</td>
<td>1</td>
<td>$21.51</td>
<td>$21.51</td>
</tr>
<tr>
<td>1/4 inch steel rod</td>
<td>1</td>
<td>$4.63</td>
<td>$4.63</td>
</tr>
<tr>
<td>1/4 inch slider</td>
<td>2</td>
<td>$27.20</td>
<td>$54.40</td>
</tr>
<tr>
<td>1/4 inch clamps (4 pack)</td>
<td>2</td>
<td>$12.40</td>
<td>$24.80</td>
</tr>
<tr>
<td>voice coil wire (30 gauge)</td>
<td>1</td>
<td>$17.28</td>
<td>$17.28</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td></td>
<td><strong>$984.59</strong></td>
</tr>
</tbody>
</table>

**Note:** All items are purchased from Amazon unless otherwise specified. Links provided for reference.

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**Vendor**

- Link
Conclusions

• **Concerns:**
  – Process of making voice coil actuator
  – Beaglebone being fast enough to read all ADCs

• Making great progress on project
Pt. 2 - Pressure Sensor

Ronald Ankner, Alex Austin, Chris Blackwood, Chris Cowan, Jacob Ginden, Richard Thornton
1.0 Mission Overview

Richard Thornton
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 and a low frequency pressure sensor combination mounted in a custom window on the skin of the rocket.
Mission Overview: **Mission Objectives**

- **Objectives**
  - Measure and record pressure data along surface of launch vehicle using:
    - High frequency pressure transducer → Fluctuations (Piezoelectric)
    - Low frequency pressure transducer → Absolute/ambient (Piezoresistive)

- **Goals**
  - Characterize the transition phases of the boundary layer through various pressures/velocities along the surface of the vehicle
Mission Overview: Expected Results

- Boundary Layer Transitions

**Mach 0-1:** Little change in static measurement

**Mach 1:** Mild fluctuations in static pressure on the order of 100-500 Pa

**Mach 1-4:** Sudden increase in static pressure, followed by high frequency fluctuations on the order of 10-100 Pa

Absolute pressure readings will range from ~250 kPa to ~5 kPa
Mission Overview: **Comprehensive Success Criteria**

- **Minimum Success Criteria**
  - Successfully sample dynamic surface flow at a minimum of 1 MHz and with at least 10-bit resolution within the window of interest

- **Comprehensive Success Criteria**
  - Successfully sample dynamic surface flow at 2 MHz with 14 or 16-bit resolution within the window of interest (180-200 seconds)
    - Expect to measure instability waves using the pressure fluctuations on the boundary layer of the launch vehicle at the given resolution and sampling rate
ConOps

Altitude

Pressure sensor data capture end
- $t \approx 2.5 \text{ min}$
- Altitude: $\approx 100 \text{ km}$

Apogee
- $t \approx 2.8 \text{ min}$
- Altitude: $\approx 115 \text{ km}$

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

High Tumble Rate
- $t \approx 4.0 \text{ min}$
- Altitude: $95 \text{ km}$

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

T = -3 min
Power on hardware

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

- Altitude: $\approx 115 \text{ km}$
Changes since STR

- Pressure Transducers purchased → expected arrival approximately 2 weeks

- CAD model for port window and pocket finalized for 3D-Printing (PLA)
  - Initial fit-testing followed by full setup testing prior to receiving canister/port

**High** Frequency, Piezoelectric Pressure transducer

Model No. **132B38**

**Low** Frequency, Piezoresistive Pressure Transducer

Model No. **MMA050V10P4A2T4A5CE**
2.0 Design Overview

Richard Thornton
*See Vibration Team’s model for more detailed full canister model.
Mechanical Design Elements - Port

Port Pocket

Pressure Transducers
High frequency (1) - 1 MHz
Low Frequency (1) - 100 Hz

Port Window
2 Sensor Mounting Holes
Symmetric about center
Aligned horizontally 1” apart

Dual SMA Connectors

*Will be updated upon arrival of sensors
Functional Block Diagram:

High Frequency Sensor

| Amplify HF data due to low voltage output |

Signal Conditioner

- Filter
- Amplifier

Low Frequency Sensor

Beaglebone PRUDAQ

| Analog data from sensors/SC is read by PRUDAQ |

ADC

Digital data stored in USB flash drive

USB Flash Drive

Provide power for all sensors and electronics

RockSat-C 2018
Mass Budget & Materials

- **Materials**
  - Standard wiring
  - PCB board components
  - LiPo batteries

- **Mechanical Hazards**
  - N/a

- **Electrical Hazards**
  - Use of LiPo’s for power storage
3.0 Subsystem Testing

Structures

Richard Thornton
## Structures - Testing

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Testing Procedures</th>
<th>Complete</th>
</tr>
</thead>
</table>
| STR.REQ.1: The pressure sensors must be mounted flush with the skin of the rocket with an appropriate sized opening | **Purpose** - Verify fit with mock port window  
**Test** - Fit test  
**Success Criteria** - Overhang < 0.05” | ![Status](progress getStatus) |
| 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 | **Purpose** - Verify design is watertight by submerging in at least 3 ft of water for at least 60 min  
**Test** - Waterproof test  
**Success Criteria** - No visible water leakage | ![Status](progress getStatus) |
| STR.REQ.3: Proper mounts for the sensors are required to be designed and machined | **Purpose** - Verify sensors can withstand vibrations and loads during launch  
**Test** - Fit test, Vibration/Load testing  
**Success Criteria** - No visible wear, loosened parts, or failures | ![Status](progress getStatus) |
Structures - Results

• No final results on port window or support structure prototypes
  – CAD models have been updated based on current sensor selection
  – Models will first be sent for 3D-Printing (once sensors arrive) for initial “fit testing” prior to machining for further waterproofing/load testing
3.0 Subsystem Testing

Electrical

Chris Blackwood & Ronnie Ankner
Electrical - Testing

Component Testing Overview:
1. Beaglebone/PRUDAQ Operation Verification
2. Pressure Sensor Testing
   a. Test and Record Output Magnitude with respect to Frequency
3. Filter testing
   a. Observe Cut off Frequency and Gain Response with Frequency
4. Amplifier Testing and Tuning
   a. Test Gain Over Frequency Range and Tune Output to 0-2V
5. Write Rate of USB
   a. Ensure Write Rate is Faster than Data Capture
Electrical - Testing

Beaglebone/PRUDAQ Operation Verification
Electrical - Testing

Pressure Sensor Testing

- Magnitude response at various frequencies from 0-2.3MHz will be recorded and plotted
- % error in frequency reading between emitter and sensor will also be recorded and plotted with respect to frequency
Electrical - Testing

Filter Testing

- Various frequencies in equal increments from 0-5 MHz will be fed through the filter
- Magnitude response will be plotted against frequency
- Cutoff frequency will be confirmed
Continuous Time Low Pass Filter

- Part #: LTC1566-1 (digikey.com)
- 7th Order Elliptic Filter
- 2.3 MHz Cutoff Frequency
  - Provides buffer for intended research range (0-2MHz)
- 40 dB Attenuation at 3.45 MHz
  - Signal level is 0.01% of passband signals at 3.45 MHz
  - Implies low noise from aliased signals
- 12 dB Gain in the Passband
**Electrical - Testing**

**Adjustable Gain Testing**

- Feed various amplitudes of signals through the op-amp and envelope detector
- If amplitude at input too small:
  - Then increase gain
- If amplitude too large:
  - Then decrease gain

![Diagram of Oscilloscope/Function Generator and AGC](attachment:diagram.png)
Electrical - Testing

Write Rate Testing

- Files of various size and randomly generated data will be generated and saved into the flash drive
- Size of the file (Bytes) and the time to write completely will be recorded
- Bytes/s will be calculated for each file and the average will be taken
- Ensure the rates calculated are faster than

\[(5 \text{ MSamples/s}) \times (10 \text{ bits/Sample}) \times (1 \text{ Byte/8 bits}) = 6.25 \text{ MB/s}\]
Signal Conditioner PCB (in progress)

- Work has begun on signal conditioner PCB
  - Schematic for amplifier, filter, and AGC circuit is currently being designed
  - Board also includes a voltage regulator and power filters
Signal Conditioner Schematic (in progress)

- Design will be completed, and parts will be ordered by April 8th
3.0 Subsystem Testing

Software

Chris Blackwood & Ronnie Ankner
Beaglebone/PRUDAQ Software Testing

```bash
option to the board. In the prudaq_capture example code, this pin is
driven by PRU0 instead. Make sure to set jumper J1 appropriately so that
the clock signal reaches the ADC.
EOF

echo bone_pwm_P9_31 > /sys/devices/bone_capemgr.9/slots
echo am33xx_pwm > /sys/devices/bone_capemgr.9/slots
sleep 1
fi

echo 'Setting GPIO clock frequency to 500kHz.'

# Max period=1e9 (1 second)
# It won't let us set period < duty, so we set duty first.
# 50% duty cycle recommended. Units are nanoseconds.
echo 1000 > /sys/devices/ocp.3/pwm_test_P9_31.13/duty
# 2000ns period = 500kHz frequency
echo 2000 > /sys/devices/ocp.3/pwm_test_P9_31.13/period
cat <<EOF
Success! Now you can read samples from /dev/beaglelogic
For example: $ hexdump /dev/beaglelogic
EOF
```
Software - Testing

Beaglebone/PRUDAQ Software Testing

This script is for use with the BeagleLogic system image as described in the PRUDAQ QuickStart. It uses GPIO pins on the BeagleBone to enable the PRUDAQ, select inputs 0 and 4, and create a 500kHz GPIO clock using a BeagleBone PWM channel. You can edit the script if you want to select other inputs or change the PWM frequency.

The script needs to be run again after a reboot.

Setting up BeagleLogic for continuous capture

Setting the switch control lines all to 0 to select inputs 0 and 4.

Setting GPIO clock frequency to 500kHz.

Success! Now you can read samples from /dev/beaglelogic

For example: $ hexdump /dev/beaglelogic

000000 00002 00512 00002 00512 00001 00512 00002 00512
000010 00001 00512 00002 00512 00002 00512 00002 00512
000020 00002 00512 00002 00512 00001 00512 00002 00513
000030 00002 00512 00002 00512 00002 00513 00002 00512
000040 00002 00512 00002 00512 00002 00512 00002 00512
000050 00002 00512 00002 00512 00002 00512 00002 00513
000060 00002 00513 00002 00512 00002 00512 00002 00512
000070 00002 00512 00001 00512 00002 00512 00002 00512
000080 00001 00512 00002 00512 00002 00512 00002 00512
000090 00002 00513 00002 00512 00002 00512 00002 00512

debian@beaglebone:-/bin$
Software - Testing

Verified functionality of Beaglebone

Awaiting sensors, currently verifying DAQ system does not constrain requirements

Conducted during full system testing, utilizing sensors and finalized signal conditioner

Flowchart:
- T-3 Activation Signal
  - Wait 3 minutes
  - Mount SD Card
  - Execute Beaglelogic Startup Script
  - Sample at 2 MHz
  - Sample at 100 Hz
  - Wait 3 minutes (Sampling Time)

Branches:
- Store in Flash Drive
- Store in Flash Drive
- Terminate Sampling Process
- Shut Down Beaglebone
4.0 Integrated Subsystem Testing Status

Richard Thornton
## Integration Subsystem Testing

### Integration Requirement

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Test</th>
<th>Success Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT.REQ.1: All components and subsystems must fit within the allotted canister volume and not interfere with other critical subsystems.</td>
<td>Fit test</td>
<td>No interference</td>
</tr>
<tr>
<td>INT.REQ.2: All subsystems must be fully functional when integrated with little to no differences in operability compared to subsystem test results.</td>
<td>Simulated performance test</td>
<td>Nominal results based on simulated environment</td>
</tr>
<tr>
<td>INT.REQ.3: Waterproofing and vibration resistance must meet similar standards as outlined in subsystem testing protocol.</td>
<td>Vibration test</td>
<td>No interference, loosened parts, or support failures</td>
</tr>
</tbody>
</table>
Integration Status

- Awaiting sensors and minor miscellaneous electronic components
- 3D Print port window for initial fit testing
  - Follow up with machined PC version for full integration testing
  - Verify functionality with finalized port window (only conducted after all other subsystems verified)
- Continue electronics integration as outlined in following slide
Integration - Testing

Full EPS Testing

- Frequency Control
- Ultrasonic Emitter
- PVC Tube
- Pressure Sensor
- Active Filter
- Op Amp Gain Control
- Envelope Detector
- Averaging Circuit
- BeagleBone
- USB

Progress: [ ]
Integration - Testing

36 Volt Alkaline Battery → FET Switch → 3 min activation → LiPo Battery Bank → FET Switch → 5 Volt Regulator

24 Volt Regulator → Signal Conditioner, Amplifier + AGC → Beaglebone and PRUDAQ → Pressure Sensor

24 Volt Regulator → FET Switch → 5 Volt Regulator

Signal
Power
Current Regulated Power
5.0 Plan for Full System Integration

Richard Thornton
Canister Integration

• Mechanical fit & vibration tests will be conducted as outlined in previous slides
  – Requires machined PC window (finalized ~2 weeks)
  – Requires high/low frequency sensors
  – Requires near finalized signal conditioner and DAQ setup

• In case of failure, additional electronic components (likely to come loose or break) are available
  – Easy maintenance access was considered

• Vibration data will validate noise isolation and structural rigidity
Mechanical & Electrical Testing

- Individual tests are more crucial at this stage (see above slides)
- Integration tests will verify functionality in simulated environments
  - Ensure no issues related to fit, noise, or rigidity issues
Plan for FMSR

• Verify subsystem functionality
• Verify capabilities in simulated environments
• Diagnose and correct any critical issues

• See timeline for expected deadlines regarding procurement, manufacturing, and testing
6.0 Project Management Update

Alex Austin
## Schedule Update

Items in Bold: Self-Imposed Deadlines

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr 3</td>
<td>Integration Subsystem test review</td>
</tr>
<tr>
<td>Apr 8</td>
<td>Components and PCB for Signal Conditioner Version 1 Ordered</td>
</tr>
<tr>
<td>Apr 8 - 14</td>
<td>Digital Sampling System Programming/Testing</td>
</tr>
<tr>
<td>Apr 10</td>
<td>Canister sent to Participants</td>
</tr>
<tr>
<td>Apr 15</td>
<td>Begin Construction for Signal Conditioner V1</td>
</tr>
<tr>
<td>Apr 10-16</td>
<td>Progress update</td>
</tr>
<tr>
<td>Apr 19</td>
<td>Signal Conditioner V1 Testing</td>
</tr>
<tr>
<td>Apr 11-24</td>
<td>Integration testing within Canister</td>
</tr>
<tr>
<td>Apr 24</td>
<td>Full Mission Simulation Test Report Presentation</td>
</tr>
<tr>
<td>Apr 30-May 4</td>
<td>Full Mission Simulation Review</td>
</tr>
<tr>
<td>May 4 - 22</td>
<td>IF V1 DOES NOT WORK: Signal Conditioner Revisions, building, and testing</td>
</tr>
<tr>
<td>May 22</td>
<td>Progress update</td>
</tr>
</tbody>
</table>
# User Guide Compliance

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Status/Reason (if needed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center of gravity in 1&quot; mid-can?</td>
<td>Yes, unconfirmed</td>
</tr>
<tr>
<td>Contained in can</td>
<td>Yes</td>
</tr>
<tr>
<td>Connected to can by 4/5 bulkheads on top and bottom only</td>
<td>Yes</td>
</tr>
<tr>
<td>Mass at 20±0.2lbs</td>
<td>Yes, unconfirmed</td>
</tr>
<tr>
<td>Shared canister clearance</td>
<td>Yes, unconfirmed</td>
</tr>
<tr>
<td>No voltage on the can</td>
<td>Yes</td>
</tr>
<tr>
<td>No voltage on multipurpose port</td>
<td>Yes</td>
</tr>
<tr>
<td>Activation wires at least 4 ft</td>
<td>Tentatively, Yes</td>
</tr>
<tr>
<td>Activation wire at least 24 gauge</td>
<td>Tentatively, Yes</td>
</tr>
<tr>
<td>Early Activation: current &lt; 1 A</td>
<td>Tentatively, Yes</td>
</tr>
<tr>
<td>T-0 Activation: current &lt; .1 A</td>
<td>Tentatively, Yes</td>
</tr>
<tr>
<td>Battery Type</td>
<td>Lithium Polymer (will not charge at Wallops)</td>
</tr>
</tbody>
</table>
## Pressure Team Planned Operating 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>Samsung MUF-64BB/AM flash Drive</td>
<td>1</td>
<td>$25.00</td>
<td>$25.00</td>
<td>Amazon</td>
</tr>
<tr>
<td>Beaglebone Black</td>
<td>1</td>
<td>$67.00</td>
<td>$67.00</td>
<td>Amazon</td>
</tr>
<tr>
<td>Beaglebone Black PRUDAQ Cape</td>
<td>1</td>
<td>$78.99</td>
<td>$78.99</td>
<td>GroupGets</td>
</tr>
<tr>
<td>PCB Piezoelectric Pressure Sensor (High frequency)</td>
<td>1</td>
<td>$695.00</td>
<td>$695.00</td>
<td>PCB</td>
</tr>
<tr>
<td>PCB Piezoelectric Pressure Sensor (Low frequency)</td>
<td>1</td>
<td>$604.00</td>
<td>$604.00</td>
<td>Omega</td>
</tr>
<tr>
<td>Micro SD Card</td>
<td>1</td>
<td>$23.00</td>
<td>$23.00</td>
<td>Amazon</td>
</tr>
<tr>
<td>Soldering Iron Tip (conical tip)</td>
<td>1</td>
<td>$12.99</td>
<td>$12.99</td>
<td>Amazon</td>
</tr>
<tr>
<td>Soldering Iron Tip (chisel tip)</td>
<td>1</td>
<td>$12.99</td>
<td>$12.99</td>
<td>Amazon</td>
</tr>
<tr>
<td>2.3 MHz Low Pass Filter</td>
<td>1</td>
<td>$10.00</td>
<td>$10.00</td>
<td>Linear Technology</td>
</tr>
<tr>
<td>Automatic Gain Control IC</td>
<td>1</td>
<td>$2.00</td>
<td>$2.00</td>
<td>Texas Instruments</td>
</tr>
<tr>
<td>Miscellaneous Electronics</td>
<td>1</td>
<td>$20.00</td>
<td>$20.00</td>
<td>N/a</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td><strong>$1,550.97</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Margin (15%)</strong></td>
<td></td>
<td></td>
<td><strong>$1,783.62</strong></td>
<td></td>
</tr>
</tbody>
</table>
## Risks and Remarks

<table>
<thead>
<tr>
<th>Risk/Concern</th>
<th>Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data collection occurs too early and fills memory before critical point</td>
<td>Check storage capacity through initial and final testing phases</td>
</tr>
<tr>
<td>Faulty wiring causing electrical shortage or improper data capture trigger</td>
<td>Assess insulation and wiring practices</td>
</tr>
<tr>
<td>Signal attenuation or clipping preventing insufficient data</td>
<td>Verify signal conditioner functionality</td>
</tr>
<tr>
<td>Data overload from slow read/write to PRUDAQ system</td>
<td>Verify read/write capabilities through iterative tests</td>
</tr>
</tbody>
</table>
Conclusions

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

• Issues:
  – Assure capabilities of low cost, commercially available system operating at 1 MHz and 10 bit resolution
  – Initiating and tracking/timestamping data collection

• Plans for action:
  – *Procure, Manufacture, and Test* subsystem components with a focus on verification of functionality prior to and following integration