The Space Owls
Integrated Subsystem Testing Review

Temple University
David Horowitz, Idris Sadiq, Tyrel Cherry, Zacharia Ismael
3/20/2019
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
1.0 Mission Overview

Tyrel Cherry
Mission Overview

- **Brief summary**
  - Optimal System Performance (Data Acquisition/Processing)
  - Payload Safety/Survivability
  - **Accurate** muon detection as a function of altitude
Success Criteria:

Minimum Success Criteria:
– Accurate data collection and storage until Apogee

Comprehensive Success Criteria:
– Correctly functional Data Acquisition with Front-End Board and SiPM’s
– Accelerometer data collection
– Safe return of the Payload
Concept of Operations

• Rationale
  – Muons contribute to the interference of signals.
  – Knowledge pertaining to muons can assist with preparation.

• Purpose of payload
  – The payload will be storing muon data into the computer board, with a side objective of acquiring accelerometer data.
  – After data collection, the stored data in the computer board should be accessed for analyzation.
ConOps (Theory 1)

Altitude

- **t ≈ 1.3 min**
  - Altitude: 75 km
  - **Muon Count: Moderate**

- **t ≈ 1.7 min**
  - Altitude: 95 km
  - **Muon Count: High**

- **t ≈ 2.8 min**
  - Altitude: ≈115 km
  - **Muon Count: Highest**

- **t ≈ 4.0 min**
  - Altitude: 95 km
  - **Muon Count: High**

- **t ≈ 4.5 min**
  - Altitude: 75 km
  - **Muon Count: High**

- **t ≈ 5.5 min**
  - **Chute Deploys**
  - **Muon Count: High**

- **t = 0 min**
  - -G switch triggered
  - All systems on
  - Begin data collection

- **t ≈ 15 min**
  - Splash Down

**End of Orion Burn**
- **t ≈ 0.6 min**
  - Altitude: 52 km
  - **Muon Count: Low**
ConOps (Theory 3)

Altitude

$t = 0$ min
- G switch triggered
- All systems on
- Begin data collection

$t \approx 1.3$ min
Altitude: 75 km
Muon Count: Highest

$t \approx 1.7$ min
Altitude: 95 km
Muon Count: Highest

$t \approx 2.8$ min
Altitude: \approx 115 km
Muon Count: Highest

$t \approx 4.0$ min
Altitude: 95 km
Muon Count: Highest

$t \approx 4.5$ min
Altitude: 75 km
Muon Count: Highest

End of Orion Burn
$t \approx 0.6$ min
Altitude: 52 km
Muon Count: Highest

$t \approx 5.5$ min
Chute Deploys
Muon Count: Lowest

$t \approx 15$ min
Splash Down

RockSat-C 2019

ISTR
Changes since STR

• There have been no design changes since the STR.
2.0 Design Overview

Idris Sadiq, Zacharia Ismael, David Horowitz
Design Overview: Canister Dimensions
Design Overview: Canister Design Model
Design Overview: Top-View Model
Design Overview: Component Design Model
Design Overview: Component Dimensions

- **Front-End Board**
- **Udoo X86 plus**
- **Battery**
- **Power Supply**

Dimensions and parts are illustrated with measurements and labels.
Functional Block Diagram:

Space Owl 2019 System Diagram

12V Battery

Power Regulator

Wallops 1.SYS.1

Udoo x86 Ultra Computer

SD card

SSD

A1702 Front End Board

ADXL377 Accelerometer

SiPM Array 1

SiPM Array 2

12v

5v

3.3v

Ethernet

Analog Device

Digital Device

Storage Media

Digital Line

Analog Line

Power Line
Hazardous Mechanical Items:

- Wires
- Connectors
- Top/Bottom payload plates that are made of Acrylic materials

Due to the short flight time, it is unlikely for the material to reach high temperature. Based on previous RockOn experiments, there was an increase in temperature of 18 Fahrenheit.
Hazardous Electrical Items:

- **LiPo batteries**
  - Potential fire hazard if major malfunction.
  - Very unlikely but could occur if batteries are shorted before entering power regulator.
Special Requests

• No special requests other than T - 3 minute activation previously requested.

*T - 3 activation allows main computer to boot completely and start data collection before launch.*
3.0 Subsystem Status

All members
Subsystem Overview

- Chassis
- Electrical (power regulator/wiring)
- Software
- Sensing
Chasis

• Testing Progress:
  - Material Hardness Test (Completed) 100%
  - Vibration Testing (Completed) 50%
Electrical Testing Status

Power regulator:

| | | 100% |
---|---|---|

Power regulator is complete. Testing and integration is complete.

Wiring:

| | | 75% |
---|---|---|

Wiring is 75% complete. Layout and most connections have been made permanent. FEB to power supply and SiPMs to FEB connections must be made permanent once new FEB is received.
Software Testing Status

Processing & Data Storage

- 3D Modeling Software has been tested extensively with positive results
- Startup scripts are running as expected with the exception of FEB software
- All software subsystems will be analyzed for CPU load this week
Sensing Testing Status

Front-End Board

- The scripting of the Front-End Board is still functional
  - Edits to the scripts have been added for customization purposes
- The board has been recently replaced.

```
1 'PP: 4b_dac_t'
1111111 0000000 0000000 0000000 ' Allows to Mask Discriminator (channel 0 to 31) [active low']
1 'Disable High Gain Track & Hold power pulsing mode (force ON)'
1 'Enable High Gain Track & Hold'
1 'Disable Low Gain Track & Hold power pulsing mode (force ON)'
1 'Enable Low Gain Track & Hold'
0 'SCA bias ( 1 = weak bias, 0 = high bias SMHz ReadOut Speed)'
0 'PP: HG Pdet'
0 'EN_HG_Pdet'
0 'PP: LG Pdet'
0 'EN_LG_Pdet'
1 'Sel SCA or PeakD HG'
1 'Sel SCA or PeakD LG'
```
4.0 Integrated Subsystem Testing Status

*All members*
Integrated Chassis Testing Status

- Dimensional testing completed to ensure all parts fit within payload
- Since payload is underweight, metal sheets will be added to the top of payload so weight requirements will be met
- Payload will be mounted to the bottom plate of the canister
- Middle plate will be used to separate the two payloads, RockSat-C and RockOn
Power regulator, FEB, and Udoo main computer have been tested together and confirmed operational. Power supply has been run integrated in system many times with no failures.

Need to stake all wiring once new FEB and Udoo are integrated into payload. These items are on order and wiring is trivial.

Full mission simulation will occur once final flight hardware has been integrated and Software + Sensing subsystems have been completed.
Integrated Software Testing Status

6-Axis Motion Data & FEB Processing

- Data acquisition and motion detection will be activated on system start via Linux shell scripts
- Testing this process has been mostly positive thus far
- Backing up data to secondary drive will be implemented next week
Integrated Sensing Testing Status

- The Front-End Board has currently been working well when integrated with the overall system.
- The power regulator deals the appropriate voltage to the Front-End Board.
- Currently unknown if the Front-End Board Data Processing can work simultaneously with accelerometer.
5.0 Plan for Full System Integration

Zacharia Ismael, David Horowitz, Idris Sadiq
Canister Integration

• A final fit test of the completed payload and measurement to confirm payload height in canister will be conducted using the old canister we have in our lab.

• This test will be conducted when the payload has been completed with ballast weights attached.

• Full system integration testing will be a mission simulation with payload mounted in canister.
Vibe Test

- Payload vibration testing completed
- It survived vibration with no issues
- Data are lost due to issues with electrical components that occurred later due to circuit failure

Expectations:
- payload is expected to survive the vibration test at WFF, and withstand a load of up to 25 Gs in all three axis
- In case of component failure, spare parts will be brought with the payload
Vibe Test
Electrical Testing

• At this point, all electrical components have been tested separately and as an integrated system. Some cross subsystem testing is pending.
  
  • Battery life has been tested by running the complete system on the batteries for 4 to 5 times the expected length of the mission.
  
  • The FEB was damaged during testing or reached end of life due to stress encountered during last years launch. A new FEB has been ordered and is expected to arrive in 1 - 2 weeks.
  
  • When the new FEB arrives, it will be calibrated with the assistance of Dr. Martoff, a Temple University physics professor who has been consulting on the detector.
Software Testing

- Software subsystem relies on encompassing electrical devices and external sensors
  - Signals from Front-end Board & SiPMs
  - Udoo 12V power

- Electrical system can be tested independent of software systems
System Level Testing

- System Level Testing:

  - A full run of muon collection and accelerometer data for approximately 15 minutes followed by a total shutdown, restart, and retrieval of data. Muon data and accelerometer data will be stored on a SD card which will be transferred to laptop for viewing.

  - The system level test will be completed after the payload with flight FEB and Udoo computer are integrated and calibrated. Scheduling is dependent on hardware delivery and physics consultant availability for calibration of detector.
Plan for FMSR

• The payload has had its subsystems integrated prior to this presentation and tested. Results indicated a working system that meets minimum success criteria. Going forward work will be focused on fine tuning software elements and replacing prototype electronic hardware with new copies for flight readiness.

• We do not foresee any major obstacles to completion of our payload at this point. A new FEB is on order and should arrive shortly. If it is not received, this would constitute a major obstacle however the supplier has been responsive and expeditious in the past.
6.0 Project Management
Update

David Horowitz
## Schedule Update

<table>
<thead>
<tr>
<th>Month</th>
<th>Item</th>
<th>Date</th>
<th>Team Member(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>Progress Update Telecon</td>
<td>3/4-8/19</td>
<td>ALL</td>
</tr>
<tr>
<td></td>
<td>Full mission simulation 1 (lab simulation)</td>
<td>3/10/2019</td>
<td>ALL</td>
</tr>
<tr>
<td></td>
<td>SiPM integration completed (if parts have arrived)</td>
<td>3/15/2019</td>
<td>David</td>
</tr>
<tr>
<td></td>
<td>Integrated Subsystem Testing Telecon</td>
<td>3/18-22/19</td>
<td>ALL</td>
</tr>
<tr>
<td></td>
<td>Final wire staking completed</td>
<td>3/29/2019</td>
<td>David</td>
</tr>
<tr>
<td>April</td>
<td>Final Payment Due</td>
<td>4/11/2019</td>
<td>Dr. Helferty/David</td>
</tr>
<tr>
<td></td>
<td>Final code due with complete software backup on usb flash drive</td>
<td>4/12/2019</td>
<td>Tyrel/Idris</td>
</tr>
<tr>
<td></td>
<td>Progress Update Telecon</td>
<td>4/15-19/19</td>
<td>ALL</td>
</tr>
<tr>
<td></td>
<td>Full mission simulation 2 (field test at Hawk Mountain if possible)</td>
<td>4/20/2019</td>
<td>David</td>
</tr>
<tr>
<td>May</td>
<td>All backup materials procured</td>
<td>5/10/2019</td>
<td>David</td>
</tr>
<tr>
<td></td>
<td>Progress Update Telecon</td>
<td>5/20-24/19</td>
<td>ALL</td>
</tr>
<tr>
<td></td>
<td>Travel tool kit packed</td>
<td>5/27/2019</td>
<td>David</td>
</tr>
<tr>
<td>June</td>
<td>Preliminary Check-In Procedure Document Due</td>
<td>6/3/2019</td>
<td>David</td>
</tr>
<tr>
<td></td>
<td>Launch Readiness Review Document Due</td>
<td>6/3/2019</td>
<td>David</td>
</tr>
<tr>
<td></td>
<td>Travel to Wallops Flight Facility</td>
<td>6/12/2019</td>
<td>ALL</td>
</tr>
<tr>
<td></td>
<td>Visual Inspection at Refugee Inn</td>
<td>6/13/2019</td>
<td>ALL</td>
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<tr>
<td></td>
<td>Vibration/Integration at Wallops</td>
<td>6/14-17/19</td>
<td>ALL</td>
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<tr>
<td></td>
<td>Presentation to next year RockSat</td>
<td>6/19/2019</td>
<td>ALL</td>
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<tr>
<td></td>
<td>Launch Day</td>
<td>6/20/2019</td>
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</tr>
<tr>
<td>July</td>
<td>Preliminary Launch Results Document Due</td>
<td>7/12/2019</td>
<td>David</td>
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<tr>
<td></td>
<td>Final Report Due</td>
<td>7/26/2019</td>
<td>ALL</td>
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</table>
Summary of Progress

- We are currently on schedule. Any items that were behind schedule during the STR presentation are now caught up with the schedule presented in the STR.

Due to damage to FEB, final wire staking will be delayed until new unit arrives. However, schedule has enough buffer to accommodate delay and remain in line with schedule on previous slide.
## 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>needs confirmation</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>5 bulkhead attachments</td>
</tr>
<tr>
<td>Mass at 20±0.2lbs</td>
<td>~2.4 lbs, need 6.1 lb ballast for ½ canister + mid mount plate (1.5 lbs) = 10 lbs</td>
</tr>
<tr>
<td>Shared canister clearance</td>
<td>Will not interfere, ½” separation between payloads</td>
</tr>
<tr>
<td>No voltage on the can</td>
<td>insulated stand-offs, mounted on plastic plates</td>
</tr>
<tr>
<td>Activation wires at least 4 ft and Teflon coated</td>
<td>yes</td>
</tr>
<tr>
<td>Activation wire at least 24 gauge</td>
<td>20 gauge</td>
</tr>
<tr>
<td>Early Activation: current &lt; 1 A</td>
<td>.76 Amps</td>
</tr>
<tr>
<td>T-0 Activation: current &lt; .1 A</td>
<td>Not using</td>
</tr>
<tr>
<td>Battery Type</td>
<td>Lithium Polymer (will not charge at Wallops)</td>
</tr>
</tbody>
</table>
# Budget

## Current Expense and Income Budget

<table>
<thead>
<tr>
<th>Purchased Item</th>
<th>Cost</th>
<th>Quantity</th>
<th>Income Source</th>
<th>Income</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Udeo x86 Ultra</td>
<td>267</td>
<td>1</td>
<td>Senior design</td>
<td>$1,000</td>
<td>$186.00</td>
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<tr>
<td>M.2 SSD Transcend MTS600</td>
<td>78.9</td>
<td>2</td>
<td>Dr. Helferty</td>
<td>As needed</td>
<td>n/a</td>
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<tr>
<td>Thermocouple Type-K Glass Braided Insulated Stainless Steel Tip</td>
<td>9.95</td>
<td>4</td>
<td></td>
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<tr>
<td>Adafruit Universal Thermocouple Amplifier MAX31856 Breakout</td>
<td>17.5</td>
<td>4</td>
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<td></td>
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<tr>
<td>ADXL345 - Triple-Axis Accelerometer (+-2g/4g/8g/16g) w/ I2C/SPI</td>
<td>17.5</td>
<td>4</td>
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<tr>
<td>Low Dropout Regulator 3.3 Volt 1.5A 3-Pin (3+Tab) TO-220 Rail</td>
<td>1.49</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Standard Regulator 5 Volt 1 Amp 3 Pin 3+ Tab TO-220</td>
<td>1.19</td>
<td>5</td>
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<tr>
<td>Standard Regulator 12 Volt 1 Amp 3 Pin 3+ Tab TO-220</td>
<td>0.29</td>
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<tr>
<td>TO-220 Heat Sink 1 Hole</td>
<td>0.99</td>
<td>5</td>
<td></td>
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<tr>
<td>83007 002100 - Wire, Hook Up, Hi Temp, PTFE, Red, 20 AWG, 100 ft, 30.48 m</td>
<td>75.64</td>
<td>1</td>
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<tr>
<td>MCDT10K35-1-RH - Tantalum Capacitor, 10 μF, 35 V, MCDT Series, ± 10%, Radial Leaded, 2.5 mm</td>
<td>2.28</td>
<td>10</td>
<td></td>
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<tr>
<td>K104K15X7RF53L2 - Multilayer Ceramic Capacitor, 0.1 μF, 50 V</td>
<td>0.22</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC0805B334K500A5.08MM - Multilayer Ceramic Capacitor, 0.33 μF, 50 V, MC Series, ± 10%, Radial Leaded, X7R</td>
<td>0.29</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C320C224K5R5TA - Multilayer Ceramic Capacitor, Gold Max, 0.22 μF, 50 V, Goldmax, 300 Series, ± 10%, Radial Leaded</td>
<td>0.81</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADXL377 - High-G Triple-Axis Accelerometer (+-200g Analog Out)</td>
<td>24.95</td>
<td>2</td>
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<td></td>
<td></td>
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<tr>
<td>Gens ace 35 800mAh 11.1V 40C LiPo Battery Pack with IST Plug</td>
<td>14.04</td>
<td>2</td>
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<td></td>
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<tr>
<td>CAEN A1702 FEB</td>
<td>2,595</td>
<td>1</td>
<td>Dr. Helferty</td>
<td></td>
<td></td>
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<tr>
<td><strong>Total:</strong></td>
<td>$3,409.00</td>
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</table>

### Additional Expenses:

- New SiPMs: ~$400
- Half canister space: $7000
- Travel to Wallops: ~$4000

**Grand Total:** $14,809
Conclusions

• Biggest concern is calibrating the front end board for optimal muon detection.

Dr. C. Jeff Martoff of the Temple University Physics Department has generously offered his assistance with this task.