The Space Owls
Subsystem Testing Review

Temple University
David Horowitz, Idris Sadiq, Tyrel Cherry, Zacharia Ismael
2/13/19
Presentation Outline

• Section 1: Mission Overview
• Section 2: Final Design Description
• Section 3: Project Management Update
• Section 4: Hardware Procurement Status
• Section 5: Subsystem Testing Results
• Section 6: Integrated Subsystem Testing Plan
• Section 7: User Guide Compliance
1.0 Mission Overview

Tyrel Cherry
Mission Overview

• Brief summary of
  – Muon detection as a function of altitude
  – Optimal System Performance (Data Acquisition/Processing)
  – Payload Safety/Survivability
Concept of Operations

• The payload will be detecting muons and storing the resulting data into the computer board.

• After data collection, the stored data will be able to be accessed in the computer board to be analyzed.
Example ConOps

- **G switch triggered**
- All systems on
- Begin data collection

**t = 0 min**

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

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

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

- **Apogee**
  - 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: Moderate

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

- **t ≈ 15 min**
  - Splash Down

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

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

- **t ≈ 15 min**
  - Splash Down
2.0 Final Design Description

David Horowitz
Zacharia Ismael
Idris Sadiq
Changes from CDR

• There have been no changes in the design since the CDR.
Mechanical Design: Payload
Mechanical Design: Payload Top View
Mechanical Design: Canister
Mechanical Design: Canister, middle plate and payload
Mechanical Design: Canister
Mechanical Design: Canister Drawing
Mechanical Design: Components

Front-End Board

Battery

Udoo X86 plus

Power Supply
Design Overview: Shared Can Logistics

• Partner: COSGC RockOn (currently)
• Communication: e-mail/teleconference
• Mount: bottom of canister

• Space Owls:
  • Mass no canister: 3.337 lbs
  • Mass with bottom plate: 5.83 lbs
  • Mass of metal sheets: 4.18 lbs
  • Total mass: 10.11 lbs
• Ports needed: None

• RockON:
  • Mass no canister: unknown
  • Mass with canister: unknown
System Design – Overall Physical Model

<table>
<thead>
<tr>
<th>Parts</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Udoo x86 Ultra</td>
<td>3.5 W x 1.7 H x 4.9 L</td>
</tr>
<tr>
<td>CAEN A 1702 FEB</td>
<td>218 W x 16 H x 1.7 L mm³</td>
</tr>
<tr>
<td>Power Supply</td>
<td>2.0 W x 1.2 H x 2.75 L</td>
</tr>
<tr>
<td>Batteries</td>
<td>3.0 W x 2.4 H x 1.2 L</td>
</tr>
<tr>
<td>Acrylic plates (top and bottoms)</td>
<td>Diameter of circle, D = 9.29</td>
</tr>
<tr>
<td>Sticks/rods</td>
<td>Diameter of rods, D = 0.3</td>
</tr>
<tr>
<td></td>
<td>Height = 5.0</td>
</tr>
</tbody>
</table>
## Subsystem Design - Mass Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Total Mass (lbf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>.20</td>
</tr>
<tr>
<td>Udoo x86</td>
<td>.27</td>
</tr>
<tr>
<td>FEB</td>
<td>.33</td>
</tr>
<tr>
<td>Battery</td>
<td>.32</td>
</tr>
<tr>
<td>SiPMs + Holder</td>
<td>.29</td>
</tr>
<tr>
<td>Chassis</td>
<td>.99</td>
</tr>
<tr>
<td>Canister</td>
<td>7.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10.1</strong></td>
</tr>
<tr>
<td><strong>Over/Under</strong></td>
<td><strong>10.1</strong></td>
</tr>
</tbody>
</table>
Hazardous Mechanical Items

**Materials that may be considered hazardous:**

1. Wires
2. Connectors
3. Top/Bottom Payload plates that are made of Acrylic materials.

Payload will experience extreme G-loading during the course of flight. In case of parachute failure, payload will experience extremely high loading in all three axis.
Electrical Design:
Electrical Design: Potential Hazards

- **LiPo batteries**
  - Potential fire hazard if major malfunction.
  - Very unlikely.
### Updated Power Budget

#### The Space Owls - Power Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Voltage (V)</th>
<th>Max Current (A)</th>
<th>Time On (min)</th>
<th>Watts</th>
<th>Ah</th>
</tr>
</thead>
<tbody>
<tr>
<td>Udoo x86</td>
<td>12.0</td>
<td>3.00</td>
<td>20</td>
<td>36.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Front End Board</td>
<td>5.0</td>
<td>0.55</td>
<td>20</td>
<td>2.75</td>
<td>0.18</td>
</tr>
<tr>
<td>Accelerometer</td>
<td>3.3</td>
<td>0.01</td>
<td>20</td>
<td>0.03</td>
<td>0.00</td>
</tr>
</tbody>
</table>

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>3.56</td>
<td></td>
<td></td>
<td>38.78</td>
<td>1.19</td>
</tr>
<tr>
<td>Total Power Capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.60</td>
</tr>
<tr>
<td>Over (+)/Under (-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.41</td>
</tr>
</tbody>
</table>

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td># of Flights Margin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.8</td>
</tr>
</tbody>
</table>

- All power comes from two, 11.1v, 800mAh, LiPo batteries wired in parallel then fed into the power regulator circuit.
Software Design

System Power On

Udoo x86 - Linux OS Boot
- Process the Following Startup Scripts
- Launch Arduino 3D modeling program
- Begin System Timing Log
  - Run FEB data acquisition software
  - Read Incoming SiPM Data and Write to Primary Storage
  - Backup Data to Secondary Drive

Has System Time exceeded 15 min?
- Yes: Udoo x86 Poweroff
- No: Continue

RockSat-C 2019
De-Scopes and Off-Ramps

• If flight tracking with 3D modeling program is not ready in time for launch, simple time-stamped accelerometer data will be used for correlation of muon detection vs altitude.
3.0 Hardware Procurement Status

David Horowitz
Zachaira Ismael
Idris Sadiq
Mechanical Elements

Manufactured materials:

- Acrylic plastic (top and bottom payload plates).
- Metal sheets to add to the bottom of payload.
Electrical Elements

- All electrical elements have been manufactured and integrated into the payload except for new SiPMs.
- SiPMs are on order and should arrive by March. One old SiPM array is on hand.
- New Udoo x86 computer is on order, delivery date is unknown due to manufacturer backlog. If new Udoo is not received, two older models are on hand, one currently in payload.
Software Elements

- Linux Shell scripts are written and configured to run on system start-up

- Scripts include instructions to launch data acquisition software. Additional software will be added shortly

- Code is completed and currently under test for 3D modeling software, timestamping, and accelerometer data recording
4.0 Subsystem Testing Results

David Horowitz
Idris Sadiq
Tyrel Cherry
Zacharia Ismael
Subsystem Overview

• Power Regulator: 
  *David Horowitz*

• Processing and Data Storage: 
  *Idris Sadiq*

• Sensing and Sensing Computation: 
  *Tyrel Cherry*

• Chassis: 
  *Zacharia Ismael*
Power Regulator

• Quick Status
  – Power Regulator has been tested and is complete.
  – Voltage output has been checked on bench and while integrated in payload.
  – Operational time has been verified.
Power Regulator

• Voltage output tested
• Tested under load in payload
• Tested for operational time
# Power Regulator

## Electrical Testing

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Successful Test Indicator</th>
<th>Testing</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Regulator will deliver 5v, 12v, and 3.3v</td>
<td>Correct readings on multimeter/scope</td>
<td>Completed</td>
<td>Successful</td>
</tr>
<tr>
<td>No voltage on canister</td>
<td>0 voltage reading between + battery terminal and canister standoffs</td>
<td>Completed</td>
<td>Successful</td>
</tr>
<tr>
<td>Early activation current &lt; 1 Amp</td>
<td>Multimeter reading on running system &lt; 1 Amp</td>
<td>Completed</td>
<td>Successful</td>
</tr>
<tr>
<td>Minimum battery life test</td>
<td>Run payload from battery for at least 20 minutes</td>
<td>Completed</td>
<td>Successful</td>
</tr>
</tbody>
</table>
Processing and Data Storage

Progress: 75%

• Quick Status
  – Linux Shell script to begin data acquisition and storage is completed. More instructions will be added.
  – 3D visualization code is complete and needs further testing
  – Timestamping code has not been implemented yet
Processing and Data Storage

- 6-axis accelerometer/gyroscope readings have been tested and modeled in 3D software. Results on following slide.
Processing and Data Storage
Sensing and Sensing Computation

• Quick Status
  – Source Code testing (Completed).
  – Data storage and interpretation (Almost complete)
  – Muon Detection (In progress).
Sensing and Sensing Computation

• FEB GUI and Root Browser.
• Newly arrived SiPM’s
• Location of data
Sensing and Sensing Computation

• **Source Code**
  – The code compiled and ran with no errors.

• **Muon Collection**
  – Undefined

• **Data storage**
  – Stored in the same directory
Chassis

Progress:

- Material Hardness Test (Completed)
- Vibration Testing (In Progress)
Chassis: Wilson BH 300 Material Hardness Testing

Material: Aluminum (6061)

<table>
<thead>
<tr>
<th>Tests</th>
<th>1500 kgf</th>
</tr>
</thead>
<tbody>
<tr>
<td>#</td>
<td>10 mm (ball indenter)</td>
</tr>
<tr>
<td>1</td>
<td>4.8</td>
</tr>
<tr>
<td>2</td>
<td>4.7</td>
</tr>
<tr>
<td>3</td>
<td>4.75</td>
</tr>
<tr>
<td>4</td>
<td>4.15</td>
</tr>
<tr>
<td>5</td>
<td>4.35</td>
</tr>
<tr>
<td>Mean, mm</td>
<td>4.55</td>
</tr>
<tr>
<td>St.dev, ±</td>
<td>0.285043856</td>
</tr>
<tr>
<td>BHN</td>
<td>87.20136915</td>
</tr>
</tbody>
</table>

\[
BHN = \frac{P}{\frac{\pi D}{2} \left(D - \sqrt{D^2 - d^2}\right)}
\]  

Where, \( P \) is the applied load in kilogram, \( D \) is the diameter of the indenter ball (10 mm), and \( d \) is average measured impression rim diameter in millimeters.
Vibration Testing: Not scheduled yet. Data will be provided.
5.0 Plan for Integrated Subsystem Testing

David Horowitz
Idris Sadiq
Zacharia Ismael
Tyrel Cherry
Plan for Subsystem Integration: Power Regulator

• The power regulator is already integrated into the payload.

• There are no major hurdles to overcome. A backup unit may be constructed if time allows.
Plan for Subsystem Integration: Processing and Data Storage

- Software systems must be tested rigorously for accuracy and robustness

- Testing and integration will be done somewhat simultaneously

- Challenges will be synchronization of events and interpreting collected data
Plan for Subsystem Integration: Sensing and Sensing Computation

- The payload is able to sense the muons adequately with no errors in the script.
- No major hurdles as of now.

http://www.learnersdictionary.com/art/ld/hurdle.gif
Plan for Subsystem Integration: Chassis

- Vibration testing will be done soon.
- No major hurdles as of now.
6.0 Project Management Update

David Horowitz
Program Management and Team Updates

*Left to Right:* Tyrel Cherry, Idris Sadiq, David Horowitz, Zacharia Ismael, Dr. Helferty
Organizational Chart

Team Organization

Advisor
Dr. Helferty

Project Manager
David Horowitz

Mechanical
Zacharia Ismael
- Mechanical Design:
  - 3D modeling
  - deck manufacture
  - canister integration

Electrical
David Horowitz
- Electrical Hardware:
  - circuit design
  - circuit construction
  - testing

Software (High level)
Tyrel Cherry
- Front End Board:
  - Data capture
  - Data transfer

Software (Low level)
Idris Sadiq
- Udoo Computer:
  - auxiliary sensor integration
  - data storage
  - scripting
## Schedule Update

<table>
<thead>
<tr>
<th>Month</th>
<th>Item</th>
<th>Date</th>
<th>Team Member(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>February</td>
<td>First Payment Due</td>
<td>2/11/2019</td>
<td>Dr. Helferty/David</td>
</tr>
<tr>
<td></td>
<td>Subsystem Testing Review Telecon</td>
<td>2/11-15/19</td>
<td>ALL</td>
</tr>
<tr>
<td></td>
<td>Chassis stabilized per vibration testing results</td>
<td>2/28/2019</td>
<td>David/Zach</td>
</tr>
<tr>
<td></td>
<td>Permanent battery installation completed</td>
<td>2/28/2019</td>
<td>David</td>
</tr>
<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>
</tr>
<tr>
<td></td>
<td>Vibration/Integration at Wallops</td>
<td>6/14-17/19</td>
<td>ALL</td>
</tr>
<tr>
<td></td>
<td>Presentation to next year RockSat</td>
<td>6/19/2019</td>
<td>ALL</td>
</tr>
<tr>
<td></td>
<td>Launch Day</td>
<td>6/20/2019</td>
<td>ALL</td>
</tr>
<tr>
<td>July</td>
<td>Preliminary Launch Results Document Due</td>
<td>7/12/2019</td>
<td>David</td>
</tr>
<tr>
<td></td>
<td>Final Report Due</td>
<td>7/26/2019</td>
<td>ALL</td>
</tr>
</tbody>
</table>
Schedule Update: continued

• Vibration testing and accelerometer code to achieve comprehensive success has not been completed. Research on determining method to discern muons vs other particle hits from captured data is ongoing.

• Responsible team members **MUST** catch up on work to be ready for full system lab test as scheduled.
7.0 User Guide Compliance

David Horowitz
## 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” mid-can?</td>
<td>confirm at Wallops</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>
Shared Can Logistics

Space Owls:

*To detect muon radiation in the upper atmosphere while gathering auxiliary sensor data to better understand the performance of our design.*

- **Mount:** Bottom
- **Mass:** $2.4 \text{ lbs} + 6.1 \text{ lbs ballast (taking into account 1.5 lb mount)}$
- **Ports:** none
- **Payload height:** 4.5 inches

RockOn:

*Teams will learn through hands-on activities, how to build a sounding rocket payload.*

- **Mount:** Mid
- **Mass:** 10 lbs
- **Ports:** none
- **Payload height:** unknown

- Communication between teams will be through teleconference / e-mail
- Combined mass with mid-mont plate will be $20 \pm 0.2 \text{ lbs}$
## 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>Uduino x86 Ultra</td>
<td>267</td>
<td>1</td>
<td>Senior design</td>
<td>$1,000</td>
<td>$186.00</td>
</tr>
<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>
</tr>
<tr>
<td>Thermocouple Type-K Glass Braid Insulated Stainless Steel Tip</td>
<td>9.95</td>
<td>4</td>
<td></td>
<td></td>
<td>---------</td>
</tr>
<tr>
<td>Adafruit Universal Thermocouple Amplifier MAX31856 Breakout</td>
<td>17.5</td>
<td>4</td>
<td></td>
<td></td>
<td>---------</td>
</tr>
<tr>
<td>ADXL345 - Triple-Axis Accelerometer (~2g/4g/8g/16g) w/ I2C/SPI</td>
<td>17.5</td>
<td>4</td>
<td></td>
<td></td>
<td>---------</td>
</tr>
<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>
</tr>
<tr>
<td>Standard Regulator 5 Volt 1 Amp 3 Pin 3+ Tab TO-220</td>
<td>1.19</td>
<td>5</td>
<td></td>
<td></td>
<td>---------</td>
</tr>
<tr>
<td>Standard Regulator 12 Volt 1 Amp 3 Pin 3+ Tab TO-220</td>
<td>0.29</td>
<td>5</td>
<td></td>
<td></td>
<td>---------</td>
</tr>
<tr>
<td>TO-220 Heat Sink 1 Hole</td>
<td>0.99</td>
<td>5</td>
<td></td>
<td></td>
<td>---------</td>
</tr>
<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>
<td></td>
<td></td>
<td>---------</td>
</tr>
<tr>
<td>MCDT10X35-1-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>
<td></td>
<td>---------</td>
</tr>
<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>MCO805834K300A5.08MM - 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>C320C224K5R7TA - 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>
<td></td>
<td></td>
<td>---------</td>
</tr>
<tr>
<td>Gens ace 3S 800mAh 11.1V 40C LiPo Battery Pack with JST Plug</td>
<td>14.04</td>
<td>2</td>
<td></td>
<td></td>
<td>---------</td>
</tr>
</tbody>
</table>

**Total:** $814.00

### Additional Expenses:

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

**Grand Total:** $12,214
Worries and Concerns

• Determining muons vs other cosmic particles from captured data:

  - Tyrel is currently researching this topic. He will make contact with the Temple University physics department and ask for assistance as they have conducted a ground based version of this experiment.

  - Journal articles regarding muon detection will be collected and parsed.
Conclusions

- Payload is almost ready to fly with ability to achieve minimum success criteria.

- Ability to achieve comprehensive success is possible with minor additions to software.

- Payload is scheduled to be completed and ready to fly by spring break.