Monarch-Two
Critical Design Review

ODU
December 1st, 2015
CDR Presentation Content

• Section 1: Mission Overview
  – Mission Overview
  – Theory and Concepts
  – Mission Requirements (detailed and finalized)
  – Expected Results
  – Concept of Operations

• Section 2: System Overview
  – Requirement/Design Changes Since CDR
  – De-Scopes/Off-Ramps
  – Mechanical Design Elements
  – Electrical Design Elements
CDR Presentation Contents

• Section 3: Subsystem Design
  – Subsystem A (SSA) (i.e. EPS)
  – Subsystem B (SSB) (i.e. STR)
  – Etc.

• Section 4: Prototyping/Analysis
  – Analysis Results
    • Interpretation to requirements
  – Prototyping Results
    • Interpretation to requirements
  – Detailed Mass Budget
  – Detailed Power Budget
  – Detailed Interfacing to Wallops
CDR Presentation Contents

• Section 5: Manufacturing Plan
  – Mechanical Elements
  – Electrical Elements
  – Software Elements

• Section 6: Testing Plan
  – System Level Testing
    • Requirements to be verified
  – Mechanical Elements
    • Requirements to be verified
  – Electrical Elements
    • Requirements to be verified
  – Software Elements
    • Requirements to be verified
CDR Presentation Contents

- Section 7: User Guide Compliance
  - Compliance Table
  - Sharing Logistics

- Section 8: Project Management Plan
  - Schedule
  - Budget
    - Mass
    - Monetary
  - Work Breakdown Structure
Mission Overview
Mission Overview

- The mission of Monarch-Two is to evaluate and design a smartphone based flight system and transmitter with flight data collection capabilities
  - Smartphone
    - Create a system that can record data and create a modulated signal for transmission through the radio
  - Transmitter
    - Create a system that can transmit a signal that can be received and demodulated at ODU (Requires Special Port)
  - Data Collection
    - Create a system that can collect and report flight data (Acceleration, Gyroscopic movement and Magnetometry)
We expect to prove that a smartphone is a viable and low cost platform for sounding rocket and balloon flights that allows faster development through software based design. This is useful, as it allows the complexity of data handling and radio communication to be simplified to a significant degree for general applications.
Theory and Concepts

• Smartphone capabilities
  – Onboard storage
  – Audio Hardware
  – High performance processor
  – Cameras
  – Battery

• Other Research
  – PhoneSat
  – STRaND
Flight Timeline

**Altitude**

- **t ≈ 0 min**: Apogee
  - Altitude: ≈115 km
  - G-switch triggered
  - Transmission begin

- **t ≈ 2.8 min**: Phone boots
  - Sensors calibrated

- **t ≈ 15 min**: Splash Down
Expected Results

• Expected Outcomes
  – Data collection at a high rate throughout flight
  – Transmission of data to ground
  – Successful operation of control system through entire flight
Success Criteria

• Minimum Success Criteria:
  – Smartphone Operation
  – Ground Station Reception

• Comprehensive Success Criteria:
  – Minimum Success
  – Full Data Downlink
  – Complete Flight Data
## Broad Functional Requirements:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logic:</td>
<td><strong>Test</strong></td>
<td>Code will be tested and shown to function under the conditions and duration of the flight.</td>
</tr>
<tr>
<td>The system will have functional logic that operates on the collected data.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmission:</td>
<td><strong>Demonstration</strong></td>
<td>The radio will be shown to operate at a measured power level that is mathematically sufficient to reach ODU.</td>
</tr>
<tr>
<td>The radio will be capable of transmitting at a power level capable of reaching ODU through the entire flight.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Generation:</td>
<td><strong>Test</strong></td>
<td>Data will be collected for the expected duration of the flight to verify proper operation.</td>
</tr>
<tr>
<td>The system will collect flight data of several types, to cover all types of expected flight movements.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structure:</td>
<td><strong>Analysis</strong></td>
<td>The system will be analyzed in solidworks to ensure proper mass distribution.</td>
</tr>
<tr>
<td>The system will conform to the balance and distribution requirements.</td>
<td></td>
<td></td>
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</table>
Functional & Design Requirements:

- Functional Requirement
  - Logic
    Smartphone
    - Signal Packet Generation (Test)
    - Data storage (Test)
  - Co-processor
    - Data Collection (Test)
    - Communication with Smartphone (Test)
  - Transmission
    - Radio Transmission (Demonstration)
  - Data Generation
    - 9DOF Sensor (Test)
    - High-G Sensor (Test)
    - High-DPS Sensor (Test)
  - Structure
    - Balanced (Analysis)
De-Scopes & Off-Ramps

- Descopes
  - Simplify Data Collection
  - Reduce code complexity

At this point funding should be fully realized, so no cost off-ramps should be encountered unless large issues arise later on.
System Overview
System Block Diagram

- 9DOF board
- High-DPS
- High-G
- Internal sensors

- SD Card
- Teensy
- Smartphone
- SD Card
- Radio

- G-Switch
- Battery bank
- Wallops Trigger
System design - Physical Model

- Batteries
- G-Switch
- Phone Holder
- Radio
- Main circuit
System design - Other views
Lack of dimensions

Unfortunately due to the holiday and our mechanical lead’s busy work schedule, we do not have images with dimensions or in-canister models.
Changes Since PDR

- Since the PDR some components have been exchanged
- The mechanical design has been firmly laid out
- Port model has been received, we will be using the two coaxial lines version.
De-Scopes and Off-Ramps

Project remains in scope and within tolerances for full realization.
Electrical Design
Sensor Board
Power Board, Including G-Switch and Wallops
Software Design Elements

- Software is behind schedule, but is the one thing I know I will be able to work on over the break.
- Bulk of sensor code will be reused code from last year, updated and refactored.
Subsystem Design
Subsystem Design Section

- Subsystems
  - Mechanical Design
    - Plates and Layout
  - Electrical Design
    - Radio
    - Smartphone
    - Sensor Package
Subsystem Design – Mechanical

- Comprised of the plates, aluminum and plastic brackets to create the payload structure.
- Interfaces with the canister
- Made of Makrolon, Aluminum and ABS plastic
- Estimated 2.5 lbs
- Subsystem is firm, will flex to incorporate other system changes.
Risk Matrix – Mechanical

MECH.RSK.1: Mission objectives are not met IF design cannot withstand flight
MECH.RSK.2: Mission objectives are not met IF system is over-mass
MECH.RSK.3: Mission objectives are not met IF 3D Printed bracket is not strong enough to handle loading
Subsystem Design – Electrical

• Subsystem ingests sensor data, then collates and transmits the data.
• Interfaces with Wallops Island through ground control relay.
• Comprised of two custom PCBs, a smartphone and a radio.
• Subsystem mass is low, most mass coming from the batteries.
• Subsystem is not final, expected revisions of the PCBs after the inevitable flaws are discovered in testing.
ELEC.RSK.1: Mission objectives are not met IF code fails in flight
ELEC.RSK.2: Mission objectives are not met IF antenna is not well designed and tested
ELEC.RSK.3: Mission objectives are not met IF solder joints fail and create open circuits
ELEC.RSK.4: Mission objectives are not met IF power system fails or overheats
## Subsystem Design – Weight Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Total Mass (lbf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batteries</td>
<td>1.5</td>
</tr>
<tr>
<td>Large Electronics</td>
<td>1.2</td>
</tr>
<tr>
<td>Small electronics</td>
<td>0.6</td>
</tr>
<tr>
<td>Hardware</td>
<td>2.5</td>
</tr>
<tr>
<td>Canister</td>
<td>6.7</td>
</tr>
<tr>
<td>Partner</td>
<td>6.5</td>
</tr>
<tr>
<td>Shared Ballast</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>19.3</strong></td>
</tr>
<tr>
<td><strong>Over/Under</strong></td>
<td><strong>(0.7)</strong></td>
</tr>
</tbody>
</table>
## Subsystem Design – Detailed Power Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Voltage (V)</th>
<th>Max Current (A)</th>
<th>Start Time (min)</th>
<th>Time On (min)</th>
<th>Watts</th>
<th>Ah</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smartphone</td>
<td>5.0</td>
<td>1.00</td>
<td>T-1</td>
<td>31</td>
<td>5.00</td>
<td>0.52</td>
</tr>
<tr>
<td>Radio</td>
<td>7.0</td>
<td>1.00</td>
<td>T=0</td>
<td>30</td>
<td>7.00</td>
<td>0.50</td>
</tr>
<tr>
<td>Sensor Board</td>
<td>3.3</td>
<td>1.00</td>
<td>T=0</td>
<td>30</td>
<td>3.30</td>
<td>0.50</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3.00</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Power</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>15.30</strong></td>
<td><strong>1.52</strong></td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Over/Under</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>5.08</strong></td>
</tr>
</tbody>
</table>

**# of Flights Margin:** 0.7
Prototyping/Analysis
Analysis Results

• Things analyzed
  – Preliminary balancing
  – Circuit revisions and improvements

• We have a solidifying idea of our layout that will create balanced results and the circuits have had several serious flaws spotted and eliminated.

• These analyses allow us to proceed with confidence and make future testing simpler.
Prototyping Results

• Nothing has yet been prototyped, as our system is mostly electrical.
• We will be prototyping the smartphone encasement as soon as the smartphone has been procured.
Manufacturing Plan
Mechanical Elements

- To be manufactured
  - Plates
  - Brackets
  - Phone Bracket (3D printed)
  - Antenna

- Procure
  - Aluminum Sheet
  - Makrolon

- Makrolon will be ordered before break, Aluminum will be bought locally
Electrical Elements

• To manufacture
  • Antenna
  • Power Board
  • Sensor Board

• Revisions
  • Two revisions are planned, three are budgeted for.

• Procurement
  • All components. Ordering should begin this week.
Software Elements

• Code Components
  • Sensor Package
    SD write
    Data collection
    Packetization
  • Smartphone
    Packetization
    Radio signal synthesis

• Timing
  • Code will be written and examined over winter break
  • Difficult to fully test code without ready hardware
Testing Plan
Mechanical Testing

• Points to test
  • Mass
  • Balance
  • Volume

• Testing Methods
  • CAD simulations
  • Physical assembly
  • Passing should be a simple method to check if the payload is within bounds.
Electrical Testing

- Points to test
  - Solder Joints
  - Circuit operation
- Testing methods
  - Pull all joints and visually inspect for quality
  - Circuit will be tested with each sensor running independently for evaluation. This dovetails nicely with code creation.
Software Testing

• Points to test
  Code functionality
  Code speed

• Testing Methods
  Run time tests to evaluate operation
  Line by line analysis and optimization for run speed
System Level Testing

- Points to test
  - Board-Plate mating
  - Connector length
  - Clearances
- Testing Methods
  - The payload assembly will be performed often and with each stage.
- Testing will be continual.
- Testing will occur in our lab.
- Testing should require minimal hand tools and personnel.
User Guide Compliance
RockSat Compliance

• Mass
  – We can easily fit within mass budget, based on our design from last year being fairly under mass.
• Volume
  – Volume is a similar situation, we have a similar layout and plate count from last year.
• Early Activation
  – Early activation is a must, we need time to allow the phone to boot into the operating system and become flight-ready.
• Special Request
  – A special port is required for our radio transmission.
Design Overview: Shared Can Logistics

- No partner assigned
- Currently operating as top payload, easily reconfigurable
- No special concerns for partner payload
Project Management
Organizational Chart

Faculty Advisors:
Dr. Bob Ash
Dr. Dimitrie Popescu
Dr. Christopher Bailey

Project Lead:
Connor Huffine

Radio:
Ashley Cox

Mechanical:
Cian Branco
Adam Horn

Electrical:
Connor Huffine
Cameron Kowaki
Ashley Smith

Sponsors:
ODU
VSGC
<table>
<thead>
<tr>
<th>Name</th>
<th>Price (USD)</th>
<th>Quantity (per payload)</th>
<th>Link</th>
<th>Description</th>
<th>Datasheet Link</th>
<th>Communication/Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smartphone</td>
<td>$55.95</td>
<td>1</td>
<td><a href="http://www.amazon.com/Samsung-Galaxy-Exynos-Quad-Quad-Core/dp/B00LSX">http://www.amazon.com/Samsung-Galaxy-Exynos-Quad-Quad-Core/dp/B00LSX</a></td>
<td>Same radio as Monarch-One Audio signal</td>
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<td>Radio</td>
<td>$50.00</td>
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<td><a href="http://www.amazon.com/Keysight-500-2000M-Plug-Free-Unknown/dp/B013V1QH8Q">http://www.amazon.com/Keysight-500-2000M-Plug-Free-Unknown/dp/B013V1QH8Q</a></td>
<td>Audio signal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Touchy 3.2</td>
<td>$10.95</td>
<td>1</td>
<td><a href="http://www.sparkfun.com/products/13726">http://www.sparkfun.com/products/13726</a></td>
<td>Sensor Package Process or</td>
<td></td>
<td>3.3v</td>
</tr>
<tr>
<td>Buttons &amp; ADC</td>
<td>$3.95</td>
<td>1</td>
<td><a href="http://www.sparkfun.com/products/13080">http://www.sparkfun.com/products/13080</a></td>
<td>Differental ADC</td>
<td></td>
<td>0v, 3v</td>
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<td>High3 Accelerometer</td>
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<td><a href="http://www.sparkfun.com/products/5337">http://www.sparkfun.com/products/5337</a></td>
<td>250g single axis</td>
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<td>5v</td>
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<tr>
<td>High5 GOGO Gyro</td>
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<td><a href="http://www.sparkfun.com/products/13270">http://www.sparkfun.com/products/13270</a></td>
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<td>3.3v</td>
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<tr>
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<td>SD card holder</td>
<td>$19.95</td>
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<td><a href="http://www.sparkfun.com/products/3357">http://www.sparkfun.com/products/3357</a></td>
<td>Latching SD card holder</td>
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<td>SPI</td>
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<tr>
<td>SD Card 1GB</td>
<td>$12.95</td>
<td>1</td>
<td><a href="http://www.sparkfun.com/products/3357">http://www.sparkfun.com/products/3357</a></td>
<td>Latching SD card holder</td>
<td></td>
<td>SPI</td>
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<tr>
<td>MOLEX 3 Pin Mate</td>
<td>$0.74</td>
<td>3</td>
<td><a href="http://www.sparkfun.com/products/1899">http://www.sparkfun.com/products/1899</a></td>
<td>Phone, Flight Package, Ground station</td>
<td></td>
<td>3.3v</td>
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<tr>
<td>Reel Kit</td>
<td>$7.85</td>
<td>1</td>
<td><a href="http://www.sparkfun.com/products/4059">http://www.sparkfun.com/products/4059</a></td>
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<td>Solar Current</td>
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<td>5v</td>
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<td>Switching SSR</td>
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<td><a href="http://www.sparkfun.com/products/5337">http://www.sparkfun.com/products/5337</a></td>
<td>Same as power SSR</td>
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<td>SMA Jack</td>
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<td><a href="http://www.sparkfun.com/products/13115">http://www.sparkfun.com/products/13115</a></td>
<td>Connection to Solar</td>
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<td></td>
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<td>Power Components</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O Switch</td>
<td>$1.95</td>
<td>1</td>
<td><a href="http://www.sparkfun.com/products/13115">http://www.sparkfun.com/products/13115</a></td>
<td>Need to remove the roller</td>
<td></td>
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<td>MOLEX 2 Pin Male</td>
<td>$0.39</td>
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<td><a href="http://www.sparkfun.com/products/1899">http://www.sparkfun.com/products/1899</a></td>
<td>G-Switch and Radio lines</td>
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<td></td>
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<tr>
<td>MOLEX 3 Pin Male</td>
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<td><a href="http://www.sparkfun.com/products/1899">http://www.sparkfun.com/products/1899</a></td>
<td>Sensor Based Power</td>
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<td>Gold State Relay</td>
<td>$8.97</td>
<td>2</td>
<td><a href="http://www.sparkfun.com/products/1899">http://www.sparkfun.com/products/1899</a></td>
<td>Relay to control power from battery</td>
<td><a href="http://www.sparkfun.com/">http://www.sparkfun.com/</a></td>
<td>0v</td>
</tr>
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<td>Battery</td>
<td>$1.13</td>
<td>4</td>
<td><a href="http://www.sparkfun.com/products/1899">http://www.sparkfun.com/products/1899</a></td>
<td>Also useful for ballast</td>
<td></td>
<td></td>
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<tr>
<td>Battery Connector</td>
<td>$1.50</td>
<td>1</td>
<td><a href="http://www.sparkfun.com/products/1899">http://www.sparkfun.com/products/1899</a></td>
<td>Connects to the battery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.3V Regulator</td>
<td>$0.49</td>
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<td><a href="http://www.sparkfun.com/products/1899">http://www.sparkfun.com/products/1899</a></td>
<td>3.3V Output</td>
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<td>3.3v</td>
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<td>Voltage Regulator</td>
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<td>1.0A Output</td>
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<td>1.0A</td>
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<td>Bury Regulator</td>
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<td><a href="http://www.sparkfun.com/products/1899">http://www.sparkfun.com/products/1899</a></td>
<td>1.0A Output</td>
<td><a href="http://www.sparkfun.com/">http://www.sparkfun.com/</a></td>
<td>1.0A</td>
</tr>
<tr>
<td>Cable Terminators</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5mm Jack (Right angle)</td>
<td>$4.04</td>
<td>1</td>
<td><a href="http://www.sparkfun.com/products/2593">http://www.sparkfun.com/products/2593</a></td>
<td>Output of phone</td>
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<td></td>
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<td>3.5mm Jack (Straight)</td>
<td>$2.15</td>
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<td><a href="http://www.sparkfun.com/products/2593">http://www.sparkfun.com/products/2593</a></td>
<td>Mic in of radio</td>
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<td></td>
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<td><a href="http://www.sparkfun.com/products/2593">http://www.sparkfun.com/products/2593</a></td>
<td>Speaker out of radio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOLEX Terminal</td>
<td>$0.20</td>
<td>10</td>
<td><a href="http://www.sparkfun.com/products/2593">http://www.sparkfun.com/products/2593</a></td>
<td>One for each pin in female jack at</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOLEX 3 Pin Female</td>
<td>$0.10</td>
<td>3</td>
<td><a href="http://www.sparkfun.com/products/2593">http://www.sparkfun.com/products/2593</a></td>
<td>Houses the terminals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOLEX 2 Pin Female</td>
<td>$0.10</td>
<td>1</td>
<td><a href="http://www.sparkfun.com/products/2593">http://www.sparkfun.com/products/2593</a></td>
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<td></td>
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<tr>
<td>USB A to Micro USB B</td>
<td>$0.12</td>
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<td><a href="http://www.amazon.com/Charger-3-speed-Portable-Micro-Cell-Phone/dp/B01D85Z12W">http://www.amazon.com/Charger-3-speed-Portable-Micro-Cell-Phone/dp/B01D85Z12W</a></td>
<td>USB to Treasy (5-Pack)</td>
<td></td>
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</tr>
<tr>
<td>USB A to Micro USB B</td>
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<td>5</td>
<td><a href="http://www.amazon.com/Charger-3-speed-Portable-Micro-Cell-Phone/dp/B01D85Z12W">http://www.amazon.com/Charger-3-speed-Portable-Micro-Cell-Phone/dp/B01D85Z12W</a></td>
<td>USB to Treasy (5-Pack)</td>
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<td></td>
</tr>
<tr>
<td>RSAs</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Power Board</td>
<td>$8.00</td>
<td>1</td>
<td><a href="http://esdpart.com">http://esdpart.com</a></td>
<td>55x9 inch, 3 copies included</td>
<td></td>
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<tr>
<td>High5 adapter</td>
<td>$1.30</td>
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<td><a href="http://esdpart.com">http://esdpart.com</a></td>
<td>55x9 inch, 3 copies included</td>
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<tr>
<td>Sensor Board</td>
<td>$24.95</td>
<td>1</td>
<td><a href="http://esdpart.com">http://esdpart.com</a></td>
<td>55x9 inch, 3 copies included</td>
<td></td>
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<tr>
<td>Hardware</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Motorizer</td>
<td>$54.18</td>
<td>1</td>
<td><a href="http://www.sparkfun.com/products/1399">http://www.sparkfun.com/products/1399</a></td>
<td>One of these should yield 4 plates (1/4&quot; x 12&quot; x 12&quot;)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminium bush</td>
<td>$10.00</td>
<td>1</td>
<td><a href="http://www.sparkfun.com/products/1399">http://www.sparkfun.com/products/1399</a></td>
<td>1/16&quot; x 12&quot; x 12&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuts, Bolts, Stardobs</td>
<td>$15.00</td>
<td>1</td>
<td><a href="http://esdpart.com">http://esdpart.com</a></td>
<td>Screw &amp; Motor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Funding

The RockSat team would like to extend sincere thanks for the support of both ODU and VSGC in this endeavour.

$7000 - VSGC
$4000 - ODU
## Team Contact Matrix

<table>
<thead>
<tr>
<th>Name</th>
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</thead>
<tbody>
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</tr>
</tbody>
</table>
To be determined, current meeting time is always acceptable.
Will gather information at next team meeting.
Project Summary

• Remaining issues
  – Need additional physical diagrams
  – Mass balance needs to be final

• Areas of concern
  – Antenna Design
  – Amount of work capable over break
Conclusion

- Continue making progress
- Before Winter Break
  - Order parts, potentially assemble revision 1
- During Break
  - First generation of code