The X-Statics
Subsystems Testing Review
February 2016

Presentation Outline

• Section 1: Mission Overview
• Section 2: Final Design Description
• Section 3: Hardware Procurement Status
• Section 4: Subsystem Testing Results
• Section 5: Plan for ISTR
• Section 6: Plan for FMSR
• Section 7: User Guide Compliance
• Section 8: Project Management Update
Mission Overview

S. Bradshaw and J. Rice
Mission Statement

The objective of our mission is to observe very low frequency (VLF) electromagnetic waves such as sferics to infer ionospheric dynamics.

Image courtesy of the Stanford VLF Group
Theory and Concepts

- Sferic (radio atmospheric signal) is a broadband electromagnetic impulse generated by natural lightning discharges.
- Electromagnetic waves such as sferics reflect from the ionosphere.
- Some energy escapes into magnetosphere.
- This energy may play a role in the removal of energetic particles from the radiation belts.
- Importance: These particles can degrade and destroy satellites especially in periods of strong solar activity.
- This reflection process has not been observed in situ.

Image courtesy of the Stanford VLF Group.
Mission Objectives

● Receive and store from electric and magnetic field signals
  ○ Picotesla for minimum magnetic field strength
  ○ Millivolt/meter for minimum electric field strength
● Store and record all data to onboard SD card
  ○ Minimum ADC sampling rate of 100 kHz
  ○ Use of 5 analog to digital channels
  ○ Estimated total data will be around 500MB which will be stored onboard the microcontroller’s SD card
Success Criteria

Minimum Success Criteria:

- Require preamplifiers to amplify signal
  - Measure sferic amplitude
  - Measure 60 Hz interference

Comprehensive Success Criteria:

- Record and store data in the xCORE microSD card from antennae through preamplifiers
Concept of Operations

Apogee
$t \approx 3$ min
Altitude $\approx 150$ km

$t \approx 1.3$ min
Altitude $\approx 75$ km
Electric field data useful

$t \approx -3$ min
Altitude $\approx 0$ km
Systems on; Ground data collection

$t \approx 5.3$ min
Altitude $\approx 75$ km
Systems off before power loss

$t \approx 15$ min
Altitude $\approx 0$ km
Splash down
Payload Location
Mechanical Changes Since CDR

U-Channel manufacturer
● Changed for time constraint and price

No other major mechanical changes made
Analog Changes Since CDR

No major system changes

Quick Update

- Prototyping and troubleshooting amplifier circuits
- Prototyping loop antennas
- Waiting on FR-4 PCB material for plate antennas
- Mostly on schedule
# Digital Electronics Actions Update

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Projected Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADC Read</td>
<td>January 7th</td>
</tr>
<tr>
<td>Magnetometer Read</td>
<td>January 14th</td>
</tr>
<tr>
<td>10 second interval SD Write</td>
<td>January 21st</td>
</tr>
<tr>
<td>Save and Shutdown method</td>
<td>January 28th</td>
</tr>
<tr>
<td>Final Core Assignments</td>
<td>February 11th</td>
</tr>
</tbody>
</table>
Changes to System
• No major changes to overall design or hardware.
• Now utilizing the Adafruit MicroSD breakout board+

Reasoning for Change
• Has a newer and easier interface
• Faster read and write time
• Sleek and lock-in connection

Schedule
• A little behind schedule
• Things to be completed: SD data writing and final core assignments
Digital Electronics Actions Update

Actions to Complete

• Within the next coming week, we should be back on schedule and ready to integrate with other subsystems.

• Code to write and save data in a timely manner is currently being written – should be complete within the next couple of days.

• Once this is done, we can then integrate with other subsystems and tinker with the core assignments to get an optimal efficient system.
Functional Block Diagram

- **Microcontroller box**
  - Xmos XCore Start Kit
    - μSD
  - Xmos XCore Start Kit
    - μSD

- **Voltage Regulator (switching)**

- **Power bus**

- **Magneto-meter**

- **Wallops Power & Telemetry Lines**
  - TE-1
  - GSE-1
  - Telem. 1
  - Telem. 2
  - Telem. 3
  - Telem. 4
  - Telem. 5

- **Voltage Regulator (linear)**

- **Preamp box**
  - Low Pass Filter
  - Low Pass Filter
  - Low Pass Filter
  - Low Pass Filter
  - Low Pass Filter

- **Plate antenna preamp/filter**
- **Loop antenna preamp/filter**

**Key**
- 28 V DC
- 5 V DC
- 24 V DC
- Amp signal
- Amp signal
- Save/shutdown
- Digital signal
Payload Overview
Electronics Box without Lid
Electronics Box with Lid
Loop Antenna
Plate Antenna
# Detailed Weight Budget

<table>
<thead>
<tr>
<th>Part</th>
<th># required</th>
<th>Mass (grams)</th>
<th>Total Mass (grams)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rocksat-X Plate</td>
<td>1</td>
<td>1553.55</td>
<td>1553.55</td>
</tr>
<tr>
<td>Loop Coils</td>
<td>3</td>
<td>489.88</td>
<td>1469.64</td>
</tr>
<tr>
<td>Plate Antennas</td>
<td>4</td>
<td>249.48</td>
<td>997.92</td>
</tr>
<tr>
<td>Electronic boxes</td>
<td>1</td>
<td>506</td>
<td>498.95</td>
</tr>
<tr>
<td>Stacking Threaded Rods</td>
<td>4</td>
<td>5</td>
<td>20.0</td>
</tr>
<tr>
<td>Nuts</td>
<td>40</td>
<td>3.40</td>
<td>136.0</td>
</tr>
<tr>
<td>Microcontroller</td>
<td>2</td>
<td>21.3</td>
<td>42.6</td>
</tr>
<tr>
<td>Wire</td>
<td>Approx. 20</td>
<td>1</td>
<td>20.0</td>
</tr>
<tr>
<td>SD card adaptor</td>
<td>2</td>
<td>3.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Magnetometer</td>
<td>1</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Linear Regulator</td>
<td>5</td>
<td>0.2</td>
<td>1.0</td>
</tr>
<tr>
<td>Op Amps</td>
<td>15</td>
<td>0.30</td>
<td>4.5</td>
</tr>
<tr>
<td>Resistors</td>
<td>50</td>
<td>0.10</td>
<td>5.0</td>
</tr>
<tr>
<td>Capacitors</td>
<td>30</td>
<td>0.20</td>
<td>6.0</td>
</tr>
</tbody>
</table>
# Detailed Weight Budget

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (grams)</td>
<td>4769.31</td>
</tr>
<tr>
<td>Total (pounds)</td>
<td>10.51</td>
</tr>
</tbody>
</table>
Materials List

- Panhead screws with matching washers (loop antennas)
- Regular screws with nuts, bolts, washers
- Circuit board (plate antennas)
- Long brackets (plate antennas)
- Bar stock (plate antennas)
- U-channels (loop antennas)
- Short brackets (loop antennas)
- Electronics box
- 24 Position D-Sub connector with Male/Female Sockets
Payload possess no hazardous mechanical items that could interfere with either the rocket systems or other payloads.
Analog Electronics Materials

- Resistors (Carbon)
- Capacitors (Ceramic)
- FR-4 Printed Circuit Boards (Circuits & Antennas)
- AWG 36 Magnet Wire (Loop Antennas)
- LT1215 Single Supply Op Amps
- LM317AHV Adjustable Linear Regulator
- MC7824CTG 24V Fixed Regulator
- Wires
Analog Electronics

LM317AHV
MC7824CTG
Analog Electronics

- The first stage is for amplification of low frequency signal with high frequency gain limiters set to filter out noise above 30kHz.
- The second stage is for amplification to a suitable level for the ADC between 0-5 volts.
- The third stage is low pass filtering to prevent the high frequency signal from aliasing with the signal we actually want to observe.
## Power Budget

**Team Name - Power Budget-Carthage College**

<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>xCORE startKIT 1</td>
<td>5.0</td>
<td>1.00</td>
<td>-3</td>
<td>8.3</td>
<td>5.00</td>
<td>0.14</td>
</tr>
<tr>
<td>xCORE startKIT 2</td>
<td>5.0</td>
<td>1.00</td>
<td>-3</td>
<td>8.3</td>
<td>5.00</td>
<td>0.14</td>
</tr>
<tr>
<td>5 Preamps</td>
<td>24.0</td>
<td>0.20</td>
<td>-3</td>
<td>8.3</td>
<td>4.80</td>
<td>0.30</td>
</tr>
</tbody>
</table>

|               | Total       | 2.20            | 14.80            | 0.58          |       |     |
|               | Total Power Capacity |                  |              | 1.00         |       |     |
|               | Over/Under  |                 |                  | 0.42          |       |     |

# of Flights Margin 1.7
## Pin Assignments: Power

<table>
<thead>
<tr>
<th>Power Pin</th>
<th>Function</th>
<th>Intended Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GSE 1</td>
<td>Power microcontrollers and preamps</td>
</tr>
<tr>
<td>2</td>
<td>Timer Event Redundant (TE-RA)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Timer Event Redundant (TE-RB)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Timer Event 1 (TE-1)</td>
<td>Send save and shutdown XCORE 1 &amp; 2</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>GSE 2</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Timer Event 2 (TE-2)</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Timer Event 3 (TE-3)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>GND</td>
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<tr>
<td>14</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>GND</td>
<td></td>
</tr>
</tbody>
</table>
## Pin Assignments: Telemetry

<table>
<thead>
<tr>
<th>Telemetry</th>
<th>Function</th>
<th>Intended Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Analog 1</td>
<td>Loop antenna 1 data</td>
</tr>
<tr>
<td>2</td>
<td>Analog 2</td>
<td>Loop antenna 2 data</td>
</tr>
<tr>
<td>3</td>
<td>Analog 3</td>
<td>Loop antenna 3 data</td>
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<tr>
<td>4</td>
<td>Analog 4</td>
<td>Dipole plate antenna 1 data</td>
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<tr>
<td>5</td>
<td>Analog 5</td>
<td>Dipole plate antenna 2 data</td>
</tr>
<tr>
<td>6</td>
<td>Analog 6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Analog 7</td>
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<td>8</td>
<td>Analog 8</td>
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<td>9</td>
<td>Analog 9</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Analog 10</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Parallel Bit 1 (MSB)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Parallel Bit 2</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Parallel Bit 3</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Parallel Bit 4</td>
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<tr>
<td>15</td>
<td>Parallel Bit 5</td>
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<tr>
<td>16</td>
<td>Parallel Bit 6</td>
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<tr>
<td>17</td>
<td>N/C</td>
<td>N/C</td>
</tr>
<tr>
<td>18</td>
<td>Ground</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Ground</td>
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<tr>
<td>20</td>
<td>Parallel Bit 7</td>
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<tr>
<td>21</td>
<td>Parallel Bit 8</td>
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<tr>
<td>22</td>
<td>Parallel Bit 9</td>
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<tr>
<td>23</td>
<td>Parallel Bit 10</td>
<td></td>
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<tr>
<td>24</td>
<td>Parallel Bit 11</td>
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<tr>
<td>25</td>
<td>Parallel Bit 12</td>
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<tr>
<td>26</td>
<td>Parallel Bit 13</td>
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<tr>
<td>27</td>
<td>Parallel Bit 14</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Parallel Bit 15</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Parallel Bit 16 (LSB)</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Parallel Read Strobe</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>N/C</td>
<td>N/C</td>
</tr>
<tr>
<td>32</td>
<td>RS-232 Data (TP1)</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>RS-232 GND (TP2)</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>N/C</td>
<td>N/C</td>
</tr>
<tr>
<td>35</td>
<td>N/C</td>
<td>N/C</td>
</tr>
<tr>
<td>36</td>
<td>Ground</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>Ground</td>
<td></td>
</tr>
</tbody>
</table>
Hazardous Electrical Items

- Payload possess no hazardous electrical items that could interfere with either the rocket systems or other payloads
Software Design

Diagram:
- **XCORE 1**
  - Start collecting data for plate antennas from ADC
  - Data Buffer
  - Write to SD card in ten second intervals
  - If time < 520 seconds
  - Repeat
  - If time >= 520 seconds
  - Begin save and shutdown

- **Power on XCORE microprocessors at T-180 seconds**

- **XCORE 2**
  - Start collecting data for loop antennas from ADC
  - Data Buffer
  - Write to SD card in ten second intervals
  - If time < 520 seconds
  - Repeat
  - If time >= 520 seconds
  - Begin save and shutdown
Software Design

Design and Functions

- ADC trigger - to retrieve data from analog electronics
- Magnetometer read - read triple axis magnetometer data
- MicroSD - read and write files to the microSD breakout board+
- Save and shutdown files prior to power off

Programming Design

- Use of multi-core processors
- Use of reduced instruction set programming
  - Allows for a faster and program, effectively increasing sampling rates
Multi-core programming

- The xCORE contains eight full cores that are separated into two tiles contained in the microprocessor. This allows us to execute many commands simultaneously and do things in a rapid time interval.

- When coding, we can implement these tiles and dedicate specific cores to different tasks. Likewise, we can dedicate many cores to a single specific task – like performing an ADC read at a very rapid sampling rate.
Update on Partnerships

- We currently have no partnerships
- Collaborators:
  - Professor Morris Cohen (Georgia Tech)
  - Offered data from ground-based receivers
De-Scopes and Off-Ramps

- There have been no changes to the scope of our experiment
- Off-Ramps:
  - If squeeze box is not compatible, revert to drilling into electrical boxes
  - If circuit board for plate antennas does not meet requirements, other options for circuit board material
Special Requests

- Extra volume
  - Use the no-go-zone close to longerons for electric field plates
- Faster sampling
  - The fastest possible sampling rate Wallops can offer us
Hardware Procurement Status

M. Becher, N. Lee, A. McCulloch, T. Shannon
Mechanical Elements

● What has been manufactured/purchased?
  ○ Corner brackets for loop antennas
  ○ U-channels (need to be cut)
  ○ Electronics box
  ○ Circuit board for plate antennas
  ○ Brackets for plate antennas
  ○ Bar stock for plate antennas
  ○ Common screws/nut/bolts

● What has not been manufactured/purchased?
  ○ Panhead screws/matching washers
  ○ 24 Position D-Sub Connector with Male/Female Sockets
Digital Electronics Hardware

XMOS XCore Start Kit

- xCORE-Analog 8-core device with integrated debugger
- PCIe connector for slice CARD add-on boards
- Core share up to 500 MHz
- MIPS architecture
- Rated up to 1MHz across four channels (250 kHz per channel)
- Weight of two xCORES: 41.6g
Digital Electronics Hardware

**Magnetometer**
- SparkFun HMC5883L
- Triple Axis Magnetometer
- Magnetic Field Range: ±8 G
- Supply Voltage: 2.5V
- Operating Current: 100µA
- Gives us direction and orientation of magnetic field
- Weight 1.1g

**MicroSD card breakout board+**
- Level shifting for faster read/write access
- Weight of two: 6.86g
- Will use 8Gb microSD cards

**Switching Voltage Regulator**
- Texas Instruments LM2675N -5.0/NOPB
- Minimum Voltage: 6.5V
- Maximum Voltage: 40V
- Voltage Output: 5V
- Switching Frequency: 260kHz
- Output Current: 1A
Digital Electronics Hardware

D-Sub Pin Connectors

- Ingress Protection: Dustproof, Waterproof
- Housing: Polyamide (PA), Nylon, Glass Filled
- 26 Pin Connections

PTFE Heat Shrink Tubing

- Zeus Dual-Shrink Tubing
- Heat shrink tubing offering a tight moisture-proof encapsulation
- Environmental seal over wires, cables, connectors, splices, terminals and other components
- Recovery Temperature: 343°C/650°F
Other various things ordered:

- Two new XCORE microcontrollers for final design.
- Female Header pins
- Breakaway male pins
- Female jumper wires

Various things that still need to be ordered

- Pin Connectors
- Heat shrink wire tubing
Analog Electronics Hardware

Antennas (Components)

- In-house
  - AWG 36 Magnet Wire
  - U-Channels
  - Brackets
- On order
  - FR-4 PCB
- Requires procurement
  - N/A (assumes no issues with current supplies)
Circuits (Components)

- In-house
  - 2 x LT1215 Single Supply Op-Amps
  - LM317AHV Adjustable Linear Regulator
  - MC7824CTG 24V Fixed Linear Regulator
  - All resistors, capacitors, and wires
- On order
  - N/A
- Requires procurement
  - Remaining number of op-amps
  - PCBs (upon completion of working circuits)
Antennas (Manufacturing)
- Loop antenna prototypes complete
  - Refining production process
- No manufacturing for plate antennas completed

Circuits (Manufacturing)
- First stage (of three) of amplifier circuit
  - Troubleshooting
  - Nothing soldered
- Linear regulator circuit
Software Elements

Completed Software

- ADC read and core assignments
  - This is a prevalent block of code that will allow the ADC to trigger 100 kHz or more. Completed relatively early and adjusted core assignments to attain sampling rate of around 155kHz
- Magnetometer read
  - The magnetometer will be sampled every one second and can be outputted to a console window

Testing Software

- This is a block of code that writes data collected from ADC to .txt files to a computer hard drive.
- Will need to be adjusted to work with MicroSD breakout board.
- SD card will need to be formatted
Software Elements

To be Completed…

- **microSD data write and save**
  - The form of the data from the ADC will remain the same and will be written as a text file every ten seconds.
  - Average line of data ~ 70 bytes
  - Theoretical amount of data over whole flight between both microcontrollers: 5.4Gb

- **Save and Shutdown Method**
  - Take signal from TE-1 to signal to microcontrollers to save and close all files.
  - Use onboard timer for redundancy.

- **Other things**
  - Work with Mechanical team to place electronics in electrical box
  - Fiddle around with the core assignment to speed up the core assignments even more so.
Subsystem Testing Results

M. Becher, S. Bradshaw, N. Lee, A. McCulloch, T. Shannon
Due to complications in ordering crucial parts, the mechanical testing has fallen behind schedule. Key parts have recently arrived and testing and construction are currently underway. Testing results will be in the ISTR in March.
Loop Antennas: Mechanical Design

4.5”

.79”

4.5”
Loop Antennas: Logistics

- 3 loop antennas
- Detect magnetic field in pT (picotesla)
- Output EMF: 1.14 μV (microvolts)
- VLF frequency: 3 kHz
- Logistics
  - Dimensions: 4.5” x 4.5” x .79”
  - Wire Gauge (Magnet Wire): AWG 36
  - Diameter of wire: .14224 mm
  - Cross Sectional Area of Wire: .01589 mm²
  - Turns: 5880
  - Resistance: 2572 ohms
  - Weight of Wire for 3 Antennas: 1.86 pounds
  - Weight of Supports for 3 Antenna: 1.38 pounds
  - Total Weight: 3.24 pounds = 1469.64 grams
- Design is final
Loop Antennas: Hardware

- U-Channel
- Bracket (From McMaster-Carr)
- AWG 36 Magnet Wire
Loop Antennas: Prototyping

Winding Set-Up

3D Printed Prototype
Loop Antennas: Prototyping

Winding Set-Up with Polystyrene, Nuts, and a Bolt

Winding the Prototype
Plate Antennas: Mechanical Design

Design Model: 0.063” thick

3.58”

5”
Plate Antennas: Logistics

- 4 plates
- Detect electric fields of $10^{-4}$ V/m
- Logistics
  - Dimensions: 3.58” by 5” by 0.063” (.09m by .127m by .0016m)
  - Curve Radius: 6”
  - Surface Area: 17.9 in$^2$ (.012 m$^2$)
  - Materials: FR4 circuit board with uncoated copper
    - Supports: Aluminum 6061
  - Weight of all four: 2.2 pounds
  - Capacitance: $3.35 \times 10^{-13}$ Farads
- Design is Final
Plate Antennas: Hardware

- Will be receiving a sample of FR-4 Circuit Board
- Isola Group Manufacturer

Multipurpose 6061 Aluminum Bar
Rectangular, 1/8" x 1/2"

Bracket (From McMaster-Carr)
Amplifier Circuits
Amplifier Circuits
Amplifier Circuits

- Successfully biased output voltage and have first stage of gain
- What we need:
  - 10000 more gain - second stage
  - Add anti-aliasing filter
  - Low input signal
  - Then manufacture on printed circuit board
Linear Regulator

- Simple test of the LM317AHV: Dropped 20V down to 14V
- Have on hand MC7824CTG
Digital Testing Results

Initial Hardware Testing Design
- Layout of all digital hardware
- Initial prototype on breadboard

Parts Soldered
- MicroSD breakout board with male headers
- Magnetometer with male headers
Digital Testing Results

Digital Electronics

- Here we can see our digital electronics wired up to the correct pin setting.

- On top we have the Adafruit MicroSD breakout board plus attached to the 3v3, DI, CS, GND, and CLK pins.

- On the bottom we have the SparkFun HMC5883L triple axis magnetometer, hooked up to GND, VCC, CLK, and SDA pins.
Software Testing Results

ADC Trigger and Read

- Data can now be read from multiple ADC pins.
- After about a ten minute performance test, we recorded an average sampling rate of 155,908.949 Hz
- Plenty enough speed to record all our data lines.
- Data in this code is written to a console window where we can observe effects.

Magnetometer Read

- Recorded triple axis magnetometer data
- Observed effects on data using common electronics as emf sources to observe fluctuations in data.
This line of code was used to test the sampling rate of the ADC.

The ADC is triggered and data from each ADC port is then sent to the unsigned array `adc_val`.

After a million iterations of the ADC trigger, we then print each value to the console and record the time it takes to output each time.

By taking the number of iterations divided by the time it took to output values, we came then calculated an average sampling rate of 155,908.949 Hz.

Plenty fast enough for the signals we are sampling, according to the Nyquist Theorem.
Plan for Integrated Subsystem Testing Review (ISTR)

N. Lee, A. McCulloch, T. Shannon
Mechanical ISTR Plan

Construction Plan - Loop Antenna
- Cut and size U-channels (3-4 days)
- Countersink holes for supports (3-4 days)
- Attach pieces using pan-head screws (1-2 weeks max.)

Construction Plan - Plate Antenna
- Upon arrival of material, test bending methods and refine process (4-5 days max.)
- Attach aluminum bar stock to back side (2-3 days)
- Attach to corner bracket supports and countersink to base plate. (1-2 weeks max.)

Construction Plan - Electronics Box
- Finalize plans for inner structure to attach electronic boards to and then construct it. (1-2 weeks)
- Cut hole for and seal around 24 Position D-Sub connector (1-2 weeks max.)
Analog Electronics ISTR Plan

Construction Plan - Antennas

- Loop
  - Finish prototypes and refine production process (2-3 days)
  - Construct final supports (1-2 weeks max.)
  - Wind all three loops (1-2 weeks max.)

- Plate
  - Upon arrival of material, test bending methods and refine production process (4-5 days max.)
  - Construct final plate antennas (1 week max.)

Construction Plan - Circuits

- Complete working first stage (1 week max.)
- Add second and third stages (2 week max.)
- Linear regulator circuit - complete
- Order and adapt to PCBs (1-2 weeks max.)

Leaves 2-4 weeks for integration and preliminary testing
Hurdles

- Bending FR-4 PCB for plate antennas
- Extracting proper gain out of first stage of amplifier circuit
- Possible issues with later gain stages of circuit
- Possible issues winding loop antennas
- Not being able to reduce input signal to expected mission levels
Integration with Analog Electronics

- Complete discrete block of code to read and to write files to microSD breakout board within the next few days.
- Work with analog electronics to integrate subsystems and get significant data from loop and electric plate antennas.

Integration with Mechanical subsystem

- Work with Mechanical team to make sure all design constraints are met and how to place electronics on base plate in the most efficient and secure way.
Plan for Full Mission Simulation Review (FMSR)

N. Lee, A. McCulloch, J. Rice, T. Shannon
Mechanical FMSR Plan

Final Tests

- Test structural integrity of the loop antennae after construction by applying pressure in different axes
- Test plate antenna structure by applying pressure in all axis.
- Test wire connections through 24 Position D-Sub Connector into electronics box to circuit boards.

All testing will commence when the construction of each piece is completed. Testing should begin before ISTR.
Final Tests

- Test antennas either through applying magnetic and electric fields and/or taking system outside for testing
- Test amplifier circuits with real signals (as opposed to signal generator)
- Troubleshoot any issues when integrating with digital system

All testing will occur a.s.a.p. to provide time cushion

Plan is to begin final testing around time of ISTR, if not before
Digital Electronics

FMSR Plan

Final Integration with Analog Electronics

- Ensure all analog electronics work flawlessly with digital electronics.
- Ensure that we are getting significant data.
- Ensure all pins and various connections are tightly held in place.

Final Integration with Mechanical Design

- Make sure all electronics are securely held within the electrical box.
- Work with Mechanical team on pin connections and heat shrinking wire tubing.
Software Testing FMSR Plan

Things to be Completed

● Write and save files to microSD breakout board
  ○ This is a requirement to ensure that our data actually saves and is written to our microSD cards.

Testing with Analog Electronics

● Every piece of software should be complete prior to FMSR and will be fully integrated with the analog subsystem:
● Main functions include: triggering ADC, magnetometer reads, writing and saving data to microSD, and shutting down system at correct time.
● Analyze data from analog signal to see if it’s significant
System Level Testing

- Test that power is being supplied correctly
- Test that antennae can send data through the preamps
- Test that preamps can communicate with the X-Cores
- Test durability of overall payload

- Conduct full mission simulations by Mid-April
User Guide Compliance

J. Rice
## User’s Guide Compliance

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center of Gravity in 1” plane of state</td>
<td>NO, adding ballast</td>
</tr>
<tr>
<td>Weight 15.0 +/- 0.5 lbs</td>
<td>NO, 10.51 lbs (adding ballast)</td>
</tr>
<tr>
<td>Max Height &lt; 5.13”</td>
<td>YES</td>
</tr>
<tr>
<td>Bottom of deck has flush mount hardware</td>
<td>YES, see image on slide 18</td>
</tr>
<tr>
<td>Within Keep-Out Zone</td>
<td>YES, see image on slide 18</td>
</tr>
<tr>
<td>Using &lt; 10 A/D Lines</td>
<td>YES, five</td>
</tr>
<tr>
<td>Using/Understand Parallel Line</td>
<td>NOT USING</td>
</tr>
<tr>
<td>Using/Understand Asynchronous Line</td>
<td>NOT USING</td>
</tr>
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</table>
## User’s Guide Compliance

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using X GSE Line(s)</td>
<td>YES, one line</td>
</tr>
<tr>
<td>Using X Non-Redundant PWR Lines (TE-1, TE-2, TE-3)</td>
<td>YES, one line</td>
</tr>
<tr>
<td>Using X Redundant Power Lines (TE-R)</td>
<td>NO</td>
</tr>
<tr>
<td>Using &lt; 1 Ah</td>
<td>YES, see Power Budget</td>
</tr>
<tr>
<td>Using &lt;= 28 V</td>
<td>YES, see Power Budget</td>
</tr>
<tr>
<td>Using RF</td>
<td>NO</td>
</tr>
<tr>
<td>Using deployable</td>
<td>NO</td>
</tr>
<tr>
<td>Whole team consists of US Persons</td>
<td>YES</td>
</tr>
<tr>
<td>Using ITAR and/or Export Controlled hardware</td>
<td>NO</td>
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</table>
Project Management Update

J. Rice
Team Picture
## Schedule

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Projected Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete SD card write code</td>
<td>February</td>
</tr>
<tr>
<td>Complete pre amplifier design</td>
<td>February</td>
</tr>
<tr>
<td>Begin prototyping of plate antennas</td>
<td>February</td>
</tr>
<tr>
<td>Begin arranging electrical box components</td>
<td>February</td>
</tr>
<tr>
<td>Complete building of loop coils</td>
<td>March</td>
</tr>
<tr>
<td>Complete building of plate antennas</td>
<td>March</td>
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<tr>
<td>Integrated Subsystems Testing Review</td>
<td>April</td>
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</table>
## Schedule Continued

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Projected Completion Date</th>
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<tbody>
<tr>
<td>Full Mission Simulation Review</td>
<td>May</td>
</tr>
<tr>
<td>Integrated Readiness Review</td>
<td>June</td>
</tr>
<tr>
<td>Ship payload to Wallops</td>
<td>June 13th</td>
</tr>
<tr>
<td>Testing in Wallops</td>
<td>June 20th-26th</td>
</tr>
<tr>
<td>Repairs</td>
<td>June 27th-July 31st</td>
</tr>
<tr>
<td>Final Integration at Wallops</td>
<td>August 1st-8th</td>
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<tr>
<td>Launch!</td>
<td>August 9th</td>
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# Budget

<table>
<thead>
<tr>
<th>Item</th>
<th>Estimated Cost</th>
<th>Total Cost</th>
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<tbody>
<tr>
<td>RockSat-X Can and Registration</td>
<td>$8500</td>
<td>$8500</td>
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<tr>
<td>Travel and lodging</td>
<td>$3300/person</td>
<td>$16500</td>
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<tr>
<td>Construction</td>
<td>$4000</td>
<td>$4000</td>
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<tr>
<td>Total</td>
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<td>$29500</td>
</tr>
<tr>
<td>Funding Source</td>
<td>Estimated Amount</td>
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<tr>
<td>-----------------------------</td>
<td>------------------</td>
<td></td>
</tr>
<tr>
<td>WSGC Grant</td>
<td>$6000</td>
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<tr>
<td>Natural sciences Division</td>
<td>$8000</td>
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<tr>
<td>Carthage Student Government</td>
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<tr>
<td>Another funding source</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$29500</strong></td>
<td></td>
</tr>
</tbody>
</table>
Team Organization Chart

Advisor: Dr. Brant Carlson

Team Lead: Jordan Rice

Conceptual Lead: Stephanie Bradshaw
  - Stephanie Bradshaw
  - Max Becher

Analog Lead: Nate Lee
  - Stephanie Bradshaw
  - Max Becher

Digital Lead: Thomas Shannon
  - Ben Weber
  - Michael Hernandez
  - Marshall Morse

Mechanical Lead: Adam McCulloch
  - Breonna McMahon
  - Ariane Boissonnas
# Availability Matrix (newest)

## The X-Statics/Carthage College:

<table>
<thead>
<tr>
<th>STR RS-X Team Availability Matrix</th>
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</thead>
</table>

**PLEASE USE MOUNTAIN TIME ZONE TIMES (MST)**

<table>
<thead>
<tr>
<th>Feb 15-19</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
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<tbody>
<tr>
<td>7:00 AM</td>
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<td>8:00 AM</td>
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<tr>
<td>9:00 AM</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:00 AM</td>
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</tr>
<tr>
<td>11:00 AM</td>
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<tr>
<td>12:00 PM</td>
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</tr>
<tr>
<td>1:00 PM</td>
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</tr>
<tr>
<td>2:00 PM</td>
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</tr>
<tr>
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</tr>
<tr>
<td>5:00 PM</td>
<td>4</td>
<td></td>
<td></td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
### Latest Contact Matrix

RSC 2016 Contact List for Carthage College

<table>
<thead>
<tr>
<th>Team Member</th>
<th>Email Address</th>
<th>Phone Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jordan Rice (team lead)</td>
<td><a href="mailto:jrice@carthage.edu">jrice@carthage.edu</a></td>
<td>8163051518</td>
</tr>
<tr>
<td>Nate Lee (analog lead)</td>
<td><a href="mailto:nlee1@carthage.edu">nlee1@carthage.edu</a></td>
<td>8473631899</td>
</tr>
<tr>
<td>Ben Weber (digital lead)</td>
<td><a href="mailto:bweber1@carthage.edu">bweber1@carthage.edu</a></td>
<td>9206763124</td>
</tr>
<tr>
<td>Adam McCulloch (mech. Lead)</td>
<td><a href="mailto:amcculloch1@carthage.edu">amcculloch1@carthage.edu</a></td>
<td>9207237376</td>
</tr>
<tr>
<td>Max Becher (analog)</td>
<td><a href="mailto:mbecher@carthage.edu">mbecher@carthage.edu</a></td>
<td>7157816152</td>
</tr>
<tr>
<td>Stephanie Bradshaw (analog)</td>
<td><a href="mailto:sbradshaw@carthage.edu">sbradshaw@carthage.edu</a></td>
<td>9208962185</td>
</tr>
<tr>
<td>Tom Shannon (digital)</td>
<td><a href="mailto:tshannon@carthage.edu">tshannon@carthage.edu</a></td>
<td>2624961711</td>
</tr>
<tr>
<td>Michael Hernandez (digital)</td>
<td><a href="mailto:mherandez3@carthage.edu">mherandez3@carthage.edu</a></td>
<td>5745180103</td>
</tr>
<tr>
<td>Ariane Boissonnas (mech.)</td>
<td><a href="mailto:aboissonnas@carthage.edu">aboissonnas@carthage.edu</a></td>
<td>6085146229</td>
</tr>
<tr>
<td>Breonna McMahon (mech.)</td>
<td><a href="mailto:bmcmahon1@carthage.edu">bmcmahon1@carthage.edu</a></td>
<td>3195411454</td>
</tr>
<tr>
<td>Brant Carlson (advisor)</td>
<td><a href="mailto:bcarlson1@carthage.edu">bcarlson1@carthage.edu</a></td>
<td>7202204869</td>
</tr>
</tbody>
</table>
Worries and Concerns

- Shaping and molding circuit board for plate antennas
- Rounding edges of U-Channels for loop antennas
- Squeeze box for electrical box
Conclusion

- Clamshell skirt detachment
- Pre-amplifier advice
- Waterproof and heat resistant wires and connectors