MEGALODON
Measuring Emitting Groundstations using Antennas Listening for Oscillating Doppler Outputs from NEXRAD
Critical Design Review

CU Boulder
Hailee Baughn, Adam Boylston, Alejandro Corral, Grace Edwards, Cody Goldman, Thomas Kisylia, Erika Polhamus, Amanda Siirola, Zachary Trahey

26 January 2017
CDR Presentation Outline

• Section 1: Mission Overview
• Section 2: System Overview
• Section 3: Subsystem Design
• Section 4: Prototyping & Analysis Plans
• Section 5: Manufacturing Plan
• Section 6: Testing Plan
• Section 7: User Guide Compliance
• Section 8: Project Management Plan (PMP)
1.0 Mission Overview

Hailee Baughn, Amanda Siirola
Mission Overview: Mission Statement

**What:** Using passive Radio Frequency (RF) technology to qualitatively analyze signal degradation as the payload reaches the ionosphere.

**Why:** As any payload launches from Earth, the signals decrease as a function of altitude and environmental factors. When payloads reach the ionosphere, signals decrease more dramatically due to variable ion density.

**How:** Our team is creating a theoretical MATLAB model to determine the projected nominal path loss due to altitude and and other environmental factors without ionospheric interference. We expect the flight data will have higher signal loss compared to the theoretical model.

**Motivation:** Communication satellites orbiting in the ionosphere can have a loss of signal (LOS) due to the signal scattering in dense regions of the ionosphere. Understanding how the ionosphere degrades signals can help us better understand and research how to avoid this phenomena.
## Mission Overview: Mission Objectives

<table>
<thead>
<tr>
<th>Level</th>
<th>Mission Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary</strong></td>
<td>● Design, build, and test RF passive array technology</td>
</tr>
<tr>
<td></td>
<td>● Receive RF signals during flight from the F-band of the ionosphere (105 - 600km)</td>
</tr>
<tr>
<td></td>
<td>● Calculate theoretical model to predict signal degradation due to environmental factors and path loss</td>
</tr>
<tr>
<td></td>
<td>● Gather, process, and analyze RF data within the S-band frequency range</td>
</tr>
<tr>
<td></td>
<td>● Integrate collected data into theoretical model to qualitatively analyze signal degradation</td>
</tr>
<tr>
<td><strong>Secondary</strong></td>
<td>● Isolate RF signals detected from known ground transmitters from noise</td>
</tr>
<tr>
<td></td>
<td>● Retrieve data that shows signal degradation during flight within ionosphere</td>
</tr>
</tbody>
</table>
Mission Overview: Theory and Concepts

- Free-space path loss (FSPL) - loss of energy/signal due to the atmosphere, line-of-sight obstructions, and presence of air molecules

- Electrons and electrically charged atoms in ionosphere scatter electromagnetic signals significantly more (refer to figure)

- Common for communication satellites to experience loss of signal due to this scattering
Mission Overview: Theory and Concepts

- Testing interference in S-band
- **S-band**: 2.0 - 4.0 GHz
- **Our Range**: 2.9 - 3.1 GHz
Mission Overview: Theory and Concepts

NEXRAD: Next Generation Weather Radar

- US Array of 159 high frequency S-band Doppler weather radar satellites
- Operates between 2.9 - 3.1 GHz
- NEXRAD operates continuously and provides severe weather coverage out 125 statute miles and storm tracking out to 250 statute miles

Specs and Parameters

- 360° rotation with maximum 19.5 tilt angle
- 1.5° beam width
  - Ideally would want to receive NEXRAD’s direct signal
  - Expect to receive sidelobes and backlobes of signal which are significantly weaker
Mission Overview: Theory and Concepts

- Beamwidth
- Boresight
- Half-Power Points
- Main beam/lobe
- Backlobes
- Sidelobes

[Diagram showing radar beamwidth, boresight, half-power points, and primary lobe with dB levels marked at various points.]
Mission Overview: Theory and Concepts

Philadelphia, PA (146.7 statute miles)

Dover, DE (88.4 statute miles)

Sterling, VA (132.7 statute miles)

Norfolk/Richmond, VA (81.7 statute miles)

*Dover and Norfolk/Richmond have a greater chance of transmitting to the payload as the rocket launches southeast
Mission Overview: Theory and Concepts

• Collecting signal amplitude vs. altitude for each antenna
• Comparing collected data to theoretical MATLAB model
• Qualitatively analyze signal degradation as the payload reaches the ionosphere
Mission Overview: Concept of Operations

Pre Flight
- Compute link budget
- Test environmental sensors
- Test signal reception

Pre Launch Ground Ops
- Power on microcontroller
- Begin collecting environmental data
- Until power off, store environmental data onboard microcontroller

Flight
- At skirt separation, TE-1 ON
- Power on RF Board
- ACS Roll and Pointing Align (antennas pointing nadir)
- Antennas can now receive signals
  - Receive until spin up
  - Data rate slowed by ADC
  - Data compressed by eval board and data capture card
  - Data stored on SSD

Splashdown & Recovery

*Note events of team in shared payload space are not included
Mission Overview: ConOps Trajectory

Altitude

Skirt Separation
- t ≈ 1:19 min
- Altitude: 82.6 km
- Activate antennas - start receiving/storing data

Apogee
- t ≈ 3:19 min
- Altitude: ≈150 km
- Within F Band of Ionosphere

End of Malemute Burn
- t ≈ 0.6 min
- Altitude: 52 km

Spin Up
- t ≈ 5:00 min
- Altitude: 95 km
- Stop receiving signals

Launch
- t = 0 min
- All systems on
- Collecting environmental data

Chute Deploys
- t ≈ 7.5 min

Splashdown
- t ≈ 15 min

Launch
- t = 0 min
- All systems on
- Collecting environmental data
## Mission Overview: ConOps Timer Event Matrix

<table>
<thead>
<tr>
<th>Event</th>
<th>Time On</th>
<th>Dwell</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSE 1</td>
<td>T-180 sec</td>
<td>485 sec</td>
<td>Minutes before launch, turns on electronic systems. Environmental sensors begin collecting data.</td>
</tr>
<tr>
<td>GSE 2</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>TE-1</td>
<td>T+110 sec</td>
<td>195 sec</td>
<td>Antennas receive power and start receiving and storing data.</td>
</tr>
<tr>
<td>TE-2</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>TE-3</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>TE-R</td>
<td>T+110 sec</td>
<td>195 sec</td>
<td>Provides backup in case TE-1 fails.</td>
</tr>
</tbody>
</table>
Mission Overview: Expected Results

- Our theoretical model will plot predicted amplitude against time.

- Payload returns amplitude with timestamps for each individual antenna.

- Ionosphere will create non-linear signal loss due to increased electron density that will scatter signal.

- We expect that flight data will have higher signal loss compared to the theoretical model.
Mission Overview: Success Criteria

Minimum Success Criteria:
- Antennas receive a signal
- Signals received are compressed and saved to SSD
- Environmental sensors power on, collect and save data

Comprehensive Success Criteria:
- Receive data from skirt separation of rocket through spin up at reentry
- Data is stored on the SSD and occasionally downlinked through telemetry
- Data is able to be integrated into MATLAB theoretical model
- Environmental sensors power on, collect and save accurate data
# Mission Overview: Top Level Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antenna elements receive signal after skirt is removed and data is saved</td>
<td>Demonstration</td>
<td>Using anechoic chamber at CU to first show low noise signals being received and known NEXRAD sources in the Denver area.</td>
</tr>
<tr>
<td>The antenna elements shall be structurally sound on the electronic box</td>
<td>Analysis</td>
<td>Using SolidWorks to construct antenna elements and stress and strain analysis to ensure stability.</td>
</tr>
<tr>
<td>The full system shall fit on a single RockSat-X deck</td>
<td>Inspection</td>
<td>Visual inspection will verify this requirement.</td>
</tr>
<tr>
<td>The system shall survive the vibration testing, vacuum testing, data collection test and known source testing</td>
<td>Test</td>
<td>The system will be subject to a known NEXRAD source and tested to receive and save data signals. During June testing the system will be subject to vibe and vacuum testing.</td>
</tr>
</tbody>
</table>
2.0 System Overview
Adam Boylston, Grace Edwards, Thomas Kisylia, Erika Polhamus, Zachary Trahey
System Overview: System Changes Since PDR

Action Items from PDR
- Add environmental sensors to monitor conditions and check power on during flight

Major changes since PDR
- No longer using a Banana Pi for the microcontroller (now using an FPGA embedded eval board)
- Added an environmental sensor PCB with humidity, temperature, pressure, and 3 axis accelerometer sensors
- No longer 3D printing the antenna elements at LMCO (CU is machining at the ITLL)
- Confirmed allotment space for the keep out zone
- Confirmed pointing request
- No longer using a flat top electronics box with all elements in one plane
- Antenna element diameter cut down by approximately 1”
- Replaced standoffs for element with a shorting post and coaxial post

Changes to mission objective and requirements
- Environmental data is now one of the mission objectives
- No longer using reverse interferometry for attitude determination and position of the rocket
System Overview: Functional Block Diagram
System Overview: Science Design

RF Board Instrumentation
• 4 Antenna Elements
• 4 Band Pass Filters (BPF)
• 4 Low Noise Amplifiers (LNA)
• 4 Analog to Digital Converters (ADC)
• Evaluation Board, Data Capture Card and SSD
System Overview: Mechanical Design

- 4 antenna mounted on a 35 degree angle plate
- Electronics components contained in a removable shell made of aluminum
- Antenna will be made of aluminum
  - Shorting post
  - Coaxial post
  - Placed on stands to mount onto plate
System Overview: Mechanical Design

Old

New
System Overview: Mechanical Design

Element

Coaxial Pin

Shorting Pin
System Overview: Mechanical Design

- The element mounting deck (gold) is also the grounding plane for the elements.
- The red shorting pin will directly connect the element to the mounting deck grounding the element.
- The blue pin then connects the element to the coaxial cable.
System Overview: Mechanical Design

5.13”

4.13”

4.78”

1.0”

35°
System Overview: Mechanical Design

- Elements may protrude into the keep out zone ~0.3”
- Excess gasket material may protrude into the keepout zone along the edge of the Ebox shell (green) > 0.1”
- Gasket material will not interfere with the electrical connections of the rocket
System Overview: Mechanical Design
## System Overview: Electrical Design

### Sensor Specifications

<table>
<thead>
<tr>
<th>Component</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BPF</strong></td>
<td>○ Meets maximum sampling frequency requirement of 3.1 GHz (3 GHz)</td>
</tr>
</tbody>
</table>
| **LNA**   | ○ Meets maximum sampling frequency requirement of 3.1 GHz (3.8 GHz)  
           | ○ Meets low noise figure requirement of less than 3dB (0.25 dB)  
           | ○ Meets low gain requirement of less than 30 dB (26 dB) |
| **ADC**   | ○ Meets maximum sampling frequency requirement of 3.1 GHz (5 GHz)  
           | ○ Meets minimum required sampling rate of 1.6 GSPS (3 GSPS) |
| **Eval Board** | ○ Supports high speed ADC  
            | ○ Meets power requirement of 12V (12V)  
            | ○ Meets minimum sampling rate of 1.6 GSPS (3 GSPS)  
            | ○ Meets minimum bit resolution of 4 bits (14 bits) |
| **Data Capture Card** | ○ Built into Eval Board  
             | ○ Supports high speed ADC  
             | ○ Allows for data to be stored on SSD and later analyzed |
| **SSD**   | ○ Supports large data storage |
System Overview: Software Design

Ground Software

- Link budget
- Theoretical model
- Post-processing of RF signal data

Flight Software

- FPGA-based evaluation board must take in large amounts of data from the antenna elements
- Save all RF data to onboard SSD, compressing if necessary
- Arduino to store environmental sensor data on onboard microSD
System Overview: Description of Partnerships

Lockheed Martin Corporation (LMCO)

- LMCO Engineers have weekly tag ups with the team and occasional in person meetings

- RF Engineers are providing guidance and assistance with learning RF concepts and developing the mission to be successful

- LMCO is providing mentorship, funding and some hardware
System Overview: De-Scopes and Off-Ramps

- Without interferometry requirement, the number of antennas can be reduced
- Decrease bit resolution of ADC to reduce data rate
- De-scope number of environmental factors in the theoretical model
- Use higher Nyquist zones to reduce data rate (reduces signal quality)
System Overview: Special Requests

- Request to go into the keep out zone with some excess gasket material
- Request for location on rocket closest to aft as possible
- Request to point 270 degrees toward Nadir
- Request to point the forward of the rocket North
System Overview: Pointing Request

Zenith

FWD/Top

Nadir

East

West

0

90

180

270
3.0 Subsystem Design

Adam Boylston, Cody Goldman, Thomas Kisylia, Erika Polhamus, Amanda Siirola, Zachary Trahey
Subsystem Design: Mechanical

• Subsystem Power: None
• Subsystem Weight: ~13.65 lbf
• Mechanically interfaces with deck plate
• No electrical interfaces with other subsystems or Wallops
• Diagrams and depictions of design and hardware are on the following slides

• Subsystem design is NOT FINAL
  – Interior electronics mounting
  – Coaxial connections to the ground plane and the Ebox-shell
  – Sealed electrical connection to the rocket electrical lines
Subsystem Design: Mechanical
Subsystem Design: Mechanical

• All the electrical components will be housed within the Electronics Shell (green)
• 5 connectors in/out of the shell (4 Coax and 1 to pass power and telemetry)
• 0.3” wall thickness to survive launch, re-entry, and splashdown
Subsystem Design: Mechanical

- The images show the interior of the electronics shell
- The maximum RF card dimensions are represented by the yellow block with 3.5” wide x 4” long x 1.5” tall
- The exact sealed connectors have not yet been finalized
- Interior mounting locations are not yet finalized
Subsystem Design: Mechanical

• The image shows a section view of the shell (green), gasket (orange and blue), mounting plate (light grey), and the deck plate (dark grey)

• The mounting plate has a 0.11” tall spacer ring to prevent over compression of the gasket (0.125” thick before compression)
Subsystem Design: Mechanical

- Exploded assembly of the payload shown on the right
- #10-32 Flat Head bolts countersunk into the deck plate pass through the mounting plate and gasket
- The bolts then thread into the Electronics Shell
Subsystem Design: Ground Software

Link Budget
- Calculates the cascaded gain, losses, and noise figures of the electronics
- Used to test gain and noise of different components to ensure closure

Theoretical Model
- Path loss \(10\log_{10}(\text{transmit power} / \text{receive power})\)
- Gains
- Noise figures
- Weather
- Season/time of day (energy from the sun)
- Distance from transmitters
- Orientation
Subsystem Design: Flight Software

- Subsystem Power: 22.5 W
- Electrically interfaces with RF Board, Environmental Sensor PCB and Wallops power and telemetry
- Hardware:
  - Eval Board, Data Capture Card, SSD and Arduino

- Subsystem Design is NOT FINAL
  - Components compatibility with system need to be checked
  - Ease of use/level of complexity of components needs to be verified
Subsystem Design: Electronic Hardware

- Subsystem Power: 27 W
- Subsystem Weight: ~1 lbf
- Electrically interfaces with antenna elements and Wallops power and telemetry
- Mechanically interfaces with mounting plate
- Hardware:
  - RF Board, BPFs, LNAs, ADCs, Eval Board, Data Capture Card, SSD
  - PCB Board, Pressure Sensor, Temperature Sensor, Humidity Sensor, Accelerometer, Arduino

- Subsystem Design is NOT FINAL
  - Components compatibility with system need to be checked
  - Ease of use/level of complexity of components needs to be verified
Subsystem Design: Risk Matrix - Structures

EPS.RSK.1: Coaxial cable disconnects from element

EPS.RSK.2: Water damage in the interior of the electronics shell

EPS.RSK.3: Structural failure of the element mounting pins
Subsystem Design: Risk Matrix - Avionics

EPS.RSK.1: FPGA setup could be too complicated given our lack of experience

EPS.RSK.2: There could be no reasonable way to store data after being processed by data capture card

EPS.RSK.3: The power requirement could exceed our limitations
Subsystem Design: Risk Matrix - Science

EPS.RSK.1: No signal is received due to incorrectly designed or manufactured antenna

EPS.RSK.2: Objectives are not met IF data cannot be interpreted due to noise

EPS.RSK.3: Signal interference is too severe to accurately determine amplitude

EPS.RSK.4: Space weather (i.e. Solar Flares) occur during flight impacting energy in ionosphere

EPS.RSK.5: Other RF payloads on rocket could interfere with signal

EPS.RSK.6: All NEXRAD stations in proximity are not transmitting
Subsystem Design: Detailed Weight Budget

- Estimated weight of 14.65 based on Solidworks mass calculations
- Electronics shell is the heaviest part at 4.57 (lbf)

<table>
<thead>
<tr>
<th>Part</th>
<th>Total Weight (lbf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deck Plate</td>
<td>3.425</td>
</tr>
<tr>
<td>Connector Plate</td>
<td>1.6</td>
</tr>
<tr>
<td>Gasket</td>
<td>0.1</td>
</tr>
<tr>
<td>Shell</td>
<td>4.57</td>
</tr>
<tr>
<td>Element Deck Plate</td>
<td>1.82</td>
</tr>
<tr>
<td>Element Assembly x4</td>
<td>1.20</td>
</tr>
<tr>
<td>Fasteners</td>
<td>~ 0.93</td>
</tr>
<tr>
<td>Electronics</td>
<td>~ 1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>14.65</strong></td>
</tr>
<tr>
<td><strong>Over/Under</strong></td>
<td><strong>(0.35)</strong></td>
</tr>
</tbody>
</table>
Subsystem Design: Detailed Weight Budget

- Center of mass lies 0.078” outside of the required 1” box
- Can be mitigated through ballast and material removal
### ExampleSat Power Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Voltage (V)</th>
<th>Current (A)</th>
<th>Time On (min)</th>
<th>Amp-Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arduino</td>
<td>12</td>
<td>0.050</td>
<td>8.08</td>
<td>0.00674</td>
</tr>
<tr>
<td>Humidity Sensor</td>
<td>5</td>
<td>200e-6</td>
<td>8.08</td>
<td>2.7e-5</td>
</tr>
<tr>
<td>Temp Sensor</td>
<td>2.5</td>
<td>10e-6</td>
<td>8.08</td>
<td>1e-6</td>
</tr>
<tr>
<td>Pressure Sensor</td>
<td>4</td>
<td>5e-6</td>
<td>8.08</td>
<td>1e-6</td>
</tr>
<tr>
<td>Evaluation Board</td>
<td>12</td>
<td>1.825</td>
<td>1.83</td>
<td>0.0989</td>
</tr>
<tr>
<td>ADC x 4</td>
<td>12</td>
<td>0.137</td>
<td>1.83</td>
<td>0.00742</td>
</tr>
<tr>
<td>LNA</td>
<td>12</td>
<td>0.240</td>
<td>1.83</td>
<td>0.013</td>
</tr>
<tr>
<td>Accelerometer</td>
<td>3.3</td>
<td>350e-6</td>
<td>8.08</td>
<td>1.9e-5</td>
</tr>
</tbody>
</table>

Total (A*hr): 0.13

Over/Under: Under
4.0 Prototyping & Analysis Plans

Hailee Baughn
Prototyping Plan:

• No prototypes currently
• Prototype plan: seals, gaskets and hermetic connectors for testing
  – Laser Cutting (gaskets)
  – Machined Aluminum (seals)
  – Order needed connectors
• Prototype Electronics Box for fitment testing
  – 3D printing
• Prototype of Antenna Elements
  – Machined Aluminum
• Plan to prototype in late February
• All will be done in house
Analysis Plan:

• No currently finished analyses

• Analysis of Noise Figure and Gain in progress
  – Determined by RF Board components (BPF, LNA, ADC)
  – Used for link budget

• Link Budget Analysis in progress
  – Characterizes signal degradation accounting for all factors except the ionosphere
5.0 Manufacturing Plan

Adam Boylston, Alejandro Corral, Cody Goldman, Thomas Kisylia
Manufacturing Plan: Mechanical Elements

Manufactured Hardware
- Electronics Box
- Element Stands
- Mounting Plate for Elements
- Mounting Plate for Electronics Box
- Gaskets and Seals
- Antenna Elements (design provided by LMCO)

Purchased Hardware
- Hermetic Connectors
- Fasteners
- Standoffs
Manufacturer Plan: Mechanical Elements

Manufacturing Schedule

- January
  - Begin prototyping elements and mounts
- February
  - Continue element prototyping, begin manufacturing of electronics mounts and interfaces
  - Electronics mounting and gasket testing
- March
  - Element manufacturing and testing (structural and RF)
  - Electronics Shell and wire connection seal tests
- April
  - Continue seal testing
  - Preliminary assembly of manufactured components
  - Manufacturing of element deck
- May
  - Integration of all components
Manufacturing Plan: Electrical Elements

Manufactured Hardware
- RF Board (LMCO)
- Environmental Sensor PCB (CU)

Purchased Hardware (COTS)
- BPFs, LNAs, ADCs and Eval Board
- Environmental Sensors (humidity, temperature, pressure, accelerometer)

Manufacturing Plan
- Post CDR, immediately acquire COTS components to check compatibility and start testing
- LMCO to manufacture RF Board in March
- CU to manufacture Environmental Sensor PCB in March
Manufacturing Plan: Software

Ground Software
- Link Budget determines viability of electrical components
  - Script for link budget is complete
  - Working alongside avionics to run the code with selected components to determine if we can close
- Theoretical Model developed independently of flight software
  - General models created by end of March
  - Code finalized by integration

Flight Software
- Developed by start of testing
- Processing software dependent RF Board components
- Will be using two programs:
  - Microcontroller - Process and store environmental data
  - RF Processing - Route to and process data for SSD, downlink to telemetry
6.0 Testing Plan

Adam Boylston, Alejandro Corral, Cody Goldman
Testing Plan: Mechanical Testing

• Vacuum Test
  ○ Bell jar - Vacuum test for Seals

• Dunk Test
  ○ Submerging to assure sealed gaskets

• Vibration Test
  ○ Assure system can withstand excessive vibration
  ○ Mounting of components in electronics box

• Fitment Test - Electronics Box
  ○ Mount components to assure proper spacing

• Testing will occur in March
Testing Plan: Electrical Testing

• Individual Component Power Test
  ○ Upon getting each component, test that it turns on and draws an expected amount of power and current

• Total System Power Test
  ○ After completing all individual tests, connect all components to a single power source to test the total power draw necessary for all components and verify that the voltage regulators can function properly.

• Expected Results Test [System Test]
  ○ With the whole system powered, collect some data while placing the system near a known RF signal. Move the system around, scale the signal power, and verify that the results make sense.
Testing Plan: Software Testing

Ground Software

• Link Budget
  ○ Already functional, used to pick components

• Theoretical Model
  ○ Run Script and compare outputted values with previous ionospheric experiments to ensure that model outputs realistic numbers

Flight Software

• Onboard compression and storing software
• Expected Results Test
  ○ use to verify software is compressing and storing data
Testing Plan: System Level Testing

• Individual antenna testing using anechoic chamber first and then NEXRAD radar (source)

• Expected Results Test (data collection)

• Mission Simulation Test (all systems)
  ○ Power on all components
  ○ Collect environmental data
  ○ Receive signals from NEXRAD
  ○ Compress and store data
  ○ Retrieve data off of SSD and micro SD card
  ○ Integrate into theoretical model

• Testing expected to take place mid to late March
7.0 User Guide Compliance

Cody Goldman
## User Guide Compliance: Summary

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Status/Reason (if needed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center of gravity in 1&quot; plane of plate?</td>
<td>YES</td>
</tr>
<tr>
<td>Weight 30.0+/-.1.0 (15.0 +/- 0.5) lbs?</td>
<td>YES</td>
</tr>
<tr>
<td>Max Height &lt; 10.75” (5.13”)</td>
<td>YES</td>
</tr>
<tr>
<td>Bottom of deck has flush mount hardware?</td>
<td>YES</td>
</tr>
<tr>
<td>Within Keep-Out Zone</td>
<td>No, but request was okay</td>
</tr>
<tr>
<td>Using &lt; 10 A/D Lines</td>
<td>6 lines</td>
</tr>
<tr>
<td>Using/Understand Parallel Line</td>
<td>No</td>
</tr>
<tr>
<td>Using/Understand Asynchronous Line</td>
<td>YES, at &lt;19200 Baud</td>
</tr>
<tr>
<td>Using X GSE Line(s)</td>
<td>GSE 1</td>
</tr>
<tr>
<td>Using X Non-Redundant PWR Lines (TE-1, TE-2, TE-3)</td>
<td>NO</td>
</tr>
<tr>
<td>Using X Redundant Power Lines (TE-R)</td>
<td>TE-R, for shell removal</td>
</tr>
<tr>
<td>Using &lt; 1 Ah (&lt; 0.5 Ah for half payload)</td>
<td>YES</td>
</tr>
<tr>
<td>Using &lt;= 28 V</td>
<td>YES</td>
</tr>
<tr>
<td>Using RF (If yes, list frequency and TX Power)</td>
<td>YES, receive only 2.9-3.1 GHz</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>
</tr>
</tbody>
</table>
## Power Connector--Customer Side

<table>
<thead>
<tr>
<th>Pin</th>
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<tbody>
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## Telemetry Connector--Customer Side

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<th>Function</th>
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<td>N/C</td>
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<tr>
<td>19</td>
<td>Ground</td>
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8.0 Project Management Plan (PMP)

Hailee Baughn, Erika Polhamus
# PMP: Team Contact Matrix

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
<th>Day Phone</th>
<th>Cell Phone</th>
<th>Receive Texts?</th>
<th>Email</th>
<th>Citizenship</th>
<th>Add to mailing list?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Manager</td>
<td>Hailee Baughn</td>
<td>720-224-4033</td>
<td>720-224-4033</td>
<td>Yes</td>
<td><a href="mailto:hailee.baughn@colorado.edu">hailee.baughn@colorado.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Systems Engineer</td>
<td>Erika Polhamus</td>
<td>714-599-1457</td>
<td>714-599-1457</td>
<td>Yes</td>
<td><a href="mailto:erika.polhamus@colorado.edu">erika.polhamus@colorado.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Structures Lead</td>
<td>Zachary Trahey</td>
<td>610-299-5916</td>
<td>610-299-5916</td>
<td>Yes</td>
<td><a href="mailto:zachary.trahy@colorado.edu">zachary.trahy@colorado.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Structures Team</td>
<td>Alejandro Corral</td>
<td>303-748-2919</td>
<td>303-748-2919</td>
<td>Yes</td>
<td>alc0355@colorado.edu_</td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Structures Team</td>
<td>Grace Edwards</td>
<td>730-532-3535</td>
<td>730-532-3535</td>
<td>No</td>
<td><a href="mailto:grace.edwards-1@colorado.edu">grace.edwards-1@colorado.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Avionics Team</td>
<td>Cody Goldman</td>
<td>214-504-8147</td>
<td>214-504-8147</td>
<td>Yes</td>
<td><a href="mailto:cody.goldman@colorado.edu">cody.goldman@colorado.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Avionics Team</td>
<td>Thomas Kislyia</td>
<td>925-286-6786</td>
<td>925-286-6786</td>
<td>Yes</td>
<td>thk9891@colorado.edu_</td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Science Lead</td>
<td>Adam Boylston</td>
<td>303-720-9755</td>
<td>303-720-9755</td>
<td>Yes</td>
<td><a href="mailto:adam.boylston@colorado.edu">adam.boylston@colorado.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
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<tr>
<td>Science Team</td>
<td>Amanda Sirola</td>
<td>303-913-7923</td>
<td>303-913-7923</td>
<td>No</td>
<td>amsi7528@colorado.edu_</td>
<td>U.S.</td>
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</table>
PMP: Team Organization Chart

Hailee Baughn
Project Manager

Erika Polhamus
Systems Engineer

Zachary Trahey
Structures Lead
  Alejandro Corral
  Grace Edwards
  Erika Polhamus

Hailee Baughn
Temp Avionics Lead
  Cody Goldman
  Thomas Kisylia

Adam Boylston
Science Lead
  Amanda Sirola
## PMP: Current Schedule

<table>
<thead>
<tr>
<th>Task</th>
<th>Team</th>
<th>Deadline</th>
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<tr>
<td>CDR</td>
<td>All</td>
<td>1/25</td>
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<tr>
<td>Confirm Payload Location</td>
<td>Management</td>
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<tr>
<td>Complete Bill of Materials</td>
<td>Management</td>
<td>2/13</td>
</tr>
<tr>
<td>Finalize Timer Event Matrix</td>
<td>Science/Avionics</td>
<td>2/13</td>
</tr>
<tr>
<td>Software Rev 1</td>
<td>Science/Avionics</td>
<td>2/20</td>
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<tr>
<td>FBD Rev 5</td>
<td>Avionics</td>
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<td>Testing Results</td>
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<tr>
<td>Hardware Procurement Status</td>
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<tr>
<td>Update Weight Budget</td>
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<tr>
<td>Finalize Pin Assignments</td>
<td>Avionics</td>
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<tr>
<td>Update Power Budget</td>
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<tr>
<td>Finalize Mechanical Drawings</td>
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<tr>
<td>Finalize Electrical Schematic</td>
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<td>Finalize Power ICDs</td>
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<td>Machine Final Parts</td>
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<tr>
<td>Start Mechanical Testing</td>
<td>Structures</td>
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<tr>
<td>Start Element Testing</td>
<td>All</td>
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<td>System Level Testing</td>
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<td>NEXRAD Signal Reception Test</td>
<td>Science/Avionics</td>
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<td>Receive RF Board</td>
<td>LMCO</td>
<td>3/22</td>
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<tr>
<td>Confirm Pin Assignments</td>
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<td>Confirm Timer Event Matrix</td>
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<td>Finalize Special Requests</td>
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<td>Start Electrical Testing</td>
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<td>Usable Software Version</td>
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<td>Determine June Operations</td>
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<td>FSMR</td>
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<td>Integration and Testing</td>
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<td>Launch Readiness Review</td>
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<td>Launch</td>
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# PMP: Monetary Budget

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<td>Lockheed Martin</td>
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<td><strong>Total</strong></td>
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<table>
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PMP: Team Mentors

COSGC
- Director: Chris Koehler
- Program Manager: Leina Hutchinson

LMCO
- Contact: Chris Herring
- Systems Engineer: Tonya Nielson
- RF Engineers: Joe Torres, Tom Hand and Josh Gustafson

CU Aerospace Engineering Department
- Professors: Trudy Schwartz
- TA’s: Kent Lee
PMP: Worries

• FPGA Evaluation Board could be too complicated (specifically the coding software)
• Breaking the Eval Board or one of the ADCs (expensive hardware)
• The ability to save the data being collected at such a high sampling rate
• Interference with other RF payloads on the rocket
• NEXRAD signals being too low (not able to be received at apogee)
• Having too much noise causing the NEXRAD signals to be indistinguishable
• Being behind schedule
Why Should Megalodon Fly?
• We want to better understand how the ionosphere affects communication satellites’ ability to receive signals. With our qualitative analysis we will be able to explain the impact ionospheric density has on signals as compared to nominal path loss factors.

Steps to get to STR (Subsystem Testing Review)
• Prototype
• Finalize component choices
• Design Environmental Sensor PCB

Questions & Concerns
• Need to know launch angle and trajectory of rocket
  – will aid in predicting signal strength and determining link budget
• Other RF payloads being similar in frequency
• Date of STR in late February
Questions?