CDR Presentation Outline

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

Tyler Nichols
Mission Overview: Mission Statement

To increase the TRL of a small re-entry spacecraft to TRL 7 by demonstrating data acquisition, communication, and TPS designs.
Mission Overview: Mission Objectives

- Test and demonstrate communication and the TPS design so that it can be applied in future research.
  - Minimum success criteria: One data packet collected by sensors shall be retrieved for analysis.

- Activation reliability in space environment.
  - Minimum success criteria: Mechanism shall eject KRUPS from rocket with all systems powered on in a verifiable manner.

- Parachute release mechanism (PRED) reliability.
  - Minimum success criteria: Parachute properly deploys and stabilizes capsule allowing for data acquisition and retrieval.
Mission Overview: Theory and Concepts

• Ablative Thermal Protection Systems (TPS) have been used and studied since the early 1950 (e.g. AVCOAT on Apollo missions)
• Significant improvements have been made in the last 15 years, with the development of low-density materials such as PICA, used on MSL, Stardust and Dragon
• A lot of the improvement are due to high-fidelity numerical methods
Mission Overview: Theory and Concepts

- Ablative TPS rely on the phase-change of the material (phenolic resin and carbon matrix) to mitigate the high heat flux

Micrographs of PICA at different magnifications. (Agrawal et al., 2013)
Mission Overview: Theory and Concepts

- No ground facility can reproduced atmospheric entry flows
- TPS are designed using a combination of numerical modeling tools and ground test campaigns
- Validation to flight conditions is always a problem, as flight data is scarce
- MSL and Orion EFT-1 have both provided such data
- Similar concepts are being designed in Belgium, Germany, and in the private sector.
Mission Overview: Concept of Operations

Capsule powers on and data collection begins

Iridium and radio power on, begin transmission

Iridium modem attempts to transmit data

Iridium establishes consistent connection

Splash down

Stable connection altitude ~30 km

Rocket apogee ~150 km

Iridium satellites ~483 miles

Parachute deploys

Transmission complete and power off

Capsule ejection

CDR 2019
## Concept of Operations

<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>N/A</td>
<td>N/A</td>
<td>N/A</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+240 sec</td>
<td>2 sec</td>
<td>Power on GoPro Cameras.</td>
</tr>
<tr>
<td>TE-2</td>
<td>T+250 sec</td>
<td>2 sec</td>
<td>Power lid solenoid, activating lid solenoid and opening KREM doors.</td>
</tr>
<tr>
<td>TE-3</td>
<td>T+255 sec</td>
<td>2 sec</td>
<td>Power ejection solenoid, activating ejection solenoid and ejecting capsule from KREM.</td>
</tr>
<tr>
<td>TE-R</td>
<td>N/a</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Mission Overview: Expected Results

- Apogee altitude: 150km
- Apogee velocity: 315 m/s
- Heat Flux: 11.8 W/cm²
Mission Overview: Success Criteria

Minimum Success Criteria:
– At least one data packet must be received for analysis in order for the mission to be considered successful.

Comprehensive Success Criteria:
– Data packets for the entire re-entry process would be the ideal amount of data to collect for analysis. This would include data obtained from the point of ejection from the rocket until parachute deployment.
# Top Level Requirements:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>The thermocouples shall collect temperature data as heat travels through the TPS material during re-entry.</td>
<td>Test</td>
<td>Thermocouples shall be placed in test vehicle and subjected to heat flux higher than those expected during flight as data is being read and verified.</td>
</tr>
<tr>
<td>The capsule shall power on and remain powered on after ejection.</td>
<td>Demonstration</td>
<td>The capsule shall be powered on and ejected in a simulated environment to verify that it is able to activate and remain powered on once removed from KREM.</td>
</tr>
<tr>
<td>The parachute shall deploy at low altitude and stabilize the capsule while simultaneously decreasing decent velocity.</td>
<td>Analysis</td>
<td>The capsule’s trajectory will be evaluated utilizing the Kentucky Trajectory Modeling Program with the appropriate entries for the parachute to yield expected trajectory upon re-entry.</td>
</tr>
<tr>
<td>The capsule shall successfully transmit data via the Iridium Satellite Network.</td>
<td>Test</td>
<td>Full mission simulation tests shall be conducted after the capsule is subjected to expected external disturbances during launch and re-entry.</td>
</tr>
</tbody>
</table>
2.0 System Overview

Collin Dietz
Design Overview: Science Design

Model material response and gas surface interactions at the macro-scale level

Application to atmospheric entry spacecraft

Extract material, chemical and transport properties at the micro-scale level
Design Overview: Science Design

- The mission will result in a better understanding of material, chemical and transport properties.
- Heat flux is the main measurement that is modeled in computational research.
- Thermocouples located at different depths to capture how heat propagates through the TPS.
- Placement and design of thermocouples are key factors in the design of KRUPS.
Systems Overview: System Changes Since PDR

- Working towards decreasing height of payload
- Finalized PRED design
- Working to finalize communications and electrical designs

- No major changes since PDR
System Overview: Mechanical Design

Filler Material

Capsule

Vibration Isolator

GoPro
System Overview: Electrical Design

[Diagram of electrical components and circuit diagrams, including labels for GYRO, ACCEL, MAG, Solid State Relay, and Teensy 3.2 PIL.]
System Overview: Electrical Design
System Overview: Software Design

Start

Initialize Ports
Initialize Flags

Initialize Sensors
Turn on Iridium Modem
Turn on Radio

If at safe Acceleration

true
Launch Parachute

false
Read Sensors
Store Data

Compress Data

Send out Compressed Data

Turn off Modem

Apply Power to GPS. Broadcast Location

End
De-Scopes and Off-Ramps

- If lead time for KREM plates is too long machinist for the mechanical engineering department will machine plates.
- If parachute is proven to be unreliable, occupy too much space, or significantly displace the center of gravity, a streamer will be implemented instead.
- If ISM Band radio cannot be implemented in a timely fashion then the flight will only include an iridium communication system.
System Overview: Special Requests

• Extra Height
  – Current design is 15.735 inches
  – Current evaluation into reducing this

• Requesting Bottom Payload Shelf
  – Full scale capsule design is not able to fit through longerons of the rocket
  – Therefore, it is necessary for the capsule to be ejected axially from the rocket utilizing the bottom payload space
3.0 Subsystem Design

Collin Dietz and Tyler Nichols
Subsystem Design

- Thermal Protection System (TPS)
- Thermoplug
- Internal Housing
- Parachute Release Device (PRED)
- Communication
- Embedded Control
- KRUPS Ejection Mechanism (KREM)
- KREM Electronics
Subsystem Design: Thermal Protection System

- Material: Cork
- Weight: no more than 1 lb
- Attached to housing utilizing RTV
- CNC milled
- 2 pieces (back-shell and fore-shell)
- 11 inches in diameter and 8.65 inches in height
- 45° Nosecone
- 3 holes for thermal plugs

Cross-Section of TPS

TPS model
TPS.RSK.1: Mission objectives are not met IF thermoplug holes penetrate surface during machining
TPS.RSK.2: Mission objectives are not met IF surface is penetrated by ejection mechanism during launch
TPS.RSK.3: Mission objectives are not met IF internal components fail due to overheating during re-entry
Subsystem Design: Thermoplug

- **Material:** Cork
- **CNC milled**
- **16 total thermocouples integrated**
  - Via three thermo-plugs embedded in heat shield
    - Stagnation point
    - Fore shell side (180° separation)
- **Thermocouples are spaced 0.10, 0.20, and 0.30 from heat shield surface as well as 0.10 inches from internal surface.**
- **4 additional thermocouples in stagnation plug at 0.40, 0.50, 0.60, and 0.70 from heat shield surface.**
Risk Matrix: Thermoplug

TP.RSK.1: Mission objectives are not met IF thermocouples stop reading temperature data during flight
TP.RSK.2: Mission objectives are not met IF thermocouples are not oriented properly within TPS material
Subsystem Design: Internal Housing

- **Material**: Nylon
- **Weight**: no more than 1 lb
- **3-D Printed**
- **Utilized as the structure for the capsule**
  - Serves as mounting point for all electrical components
  - Supports TPS
  - Houses parachute and release device

![Internal Housing Cross-Section](image1)
![Internal Housing Structure](image2)
Risk Matrix: Internal Housing

IH.RSK.1: Mission objectives are not met IF housing does not survive splashdown damaging internal electronics
IH.RSK.2: Mission objectives are not met IF housing is not properly sealed damaging internal electronics upon splashdown
Subsystem Design: Parachute Release Device

- Material: Rip-Stop Nylon
- Weight: 0.5 lb
- Annular
- Currently 48 inches in diameter
- Decent speed approximately 17 ft/s
- Spring ejection mechanism
- Triggered utilizing accelerometer
- Release acceleration determined by dynamic pressure at desired altitude and drag force

Annular parachute design
PRD.RSK.1: Mission objectives are not met IF parachute does not deploy at an appropriate altitude or at all
PRD.RSK.2: Mission objectives are not met IF parachute or shock cord does not survive deployment forces
PRD.RSK.3: Mission objectives are not met IF significant damage to the capsule occurs due to recontact
Subsystem Design: Communications

- **Iridium**
  - NAL Research Corporation Iridium Modem (Model 9523N)
  - NAL Research Corporation Antenna (Model SYN7391-C)
  - Operating Frequencies: 1616 to 1626.5 MHz
- Also utilizing ISM Band Radios
- Weight: expected no more than 1.5 lbs
Risk Matrix: Communication

COM.RSK.1: Mission objectives are not met IF the capsule is not able to connect to the Iridium Satellite Network.

COM.RSK.2: Mission objectives are not met IF no connection to the ground station is made via the ISM band radios.
Subsystem Design: Embedded Control

- Weight to not exceed .5 lbs
- PJRC Teensy 3.5 micro-controller
- SD card for storage
- Custom designed instrument board
  - Low G Accelerometer
  - Gyroscope, and Magnetic Compass
  - Thermocouple to Digital Converter
  - Flash storage

PCB housing embedded control
EC.RSK.1: Mission objectives are not met if embedded control fails or faults
EC.RSK.2: Mission objectives are not met if sensors fail to produce data
EC.RSK.3: Mission objectives are not met if battery power does not last long enough to transmit enough data
Subsystem Design: KRUPS Ejection Mechanism

- Material: Aluminum with Nylon Filler
- Weight: no more than 20 lbs
- Utilizes timer events 1, 2, and 3 to activate and eject capsule as well as activate camera system
- Solenoids used to open doors as well as eject capsule
- Contains 2 Go-Pro cameras to capture ejection
- Current issues with activation design

KREM on Payload shelf  
Bottom view  
Doors open
Subsystem Design: KRUPS Ejection Mechanism
Risk Matrix: KRUPS Ejection Mechanism

EM.RSK.1: Mission objectives are not met IF capsule is not properly powered on and activated before ejection
EM.RSK.2: Mission objectives are not met IF capsule is not ejected
EM.RSK.3: Mission objectives are not met IF ejection mechanism damages capsule during launch
Subsystem Design: KREM Electronics

- **Two solenoids**
  - Ejection (Push) Solenoid
    - Nominal Voltage: 28 V
  - Door (Pull) Solenoid
    - Currently under evaluation
  - Activated utilizing timer event from rocket

- **GoPro Cameras (2)**
  - Data stored on SD cards placed in protected environment utilizing breakout SD cords
  - Activated utilizing timer event from rocket

- **Activation Connection**
  - KREM electronics connect to the internal capsule electronics via a connection on capsule lid
  - Previously 3.5 mm head phone connecter, under redesign
Risk Matrix: KREM Electronics

KE.RSK.1: Mission objectives are not met if KREM board does not function as designed during the ejection sequence
KE.RSK.2: Mission objectives are not met if door solenoid does not activate
KE.RSK.3: Mission objectives are not met if push solenoid does not activate
## Example Sat Weight Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Total Weight (lbf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPS</td>
<td>1</td>
</tr>
<tr>
<td>KREM</td>
<td>17</td>
</tr>
<tr>
<td>Payload Deck</td>
<td>3.5</td>
</tr>
<tr>
<td>Internal Housing</td>
<td>6</td>
</tr>
<tr>
<td>Electrical</td>
<td>0.5</td>
</tr>
<tr>
<td>Communication</td>
<td>1.5</td>
</tr>
<tr>
<td>Embedded Control</td>
<td>0.5</td>
</tr>
<tr>
<td>PRED</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>30.5</strong></td>
</tr>
<tr>
<td><strong>Over/Under</strong></td>
<td><strong>(0.5)</strong></td>
</tr>
</tbody>
</table>
## Subsystem Design: Detailed Power Budget

### University of Kentucky - Power Budget

<table>
<thead>
<tr>
<th>12/10/18</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wallops Power Line</td>
<td>Subsystem</td>
</tr>
<tr>
<td>GSE1/2</td>
<td>KREM Door</td>
</tr>
<tr>
<td></td>
<td>KREM Cameras</td>
</tr>
<tr>
<td></td>
<td>KREM Ejector</td>
</tr>
<tr>
<td></td>
<td>KRUPS Activation</td>
</tr>
<tr>
<td>TE1/2/3/R</td>
<td>GSE 1/2 Total</td>
</tr>
<tr>
<td></td>
<td>TE1/2/3/R Total</td>
</tr>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td>Total Power Capacity</td>
</tr>
<tr>
<td></td>
<td>Over/Under</td>
</tr>
<tr>
<td></td>
<td># of Flights Margin</td>
</tr>
</tbody>
</table>

---

[Image of University of Kentucky logo]  
[Image of GSE 1/2 logo]  
[Image of TE1/2/3/R logo]  
[Image of Wallops Power Line logo]  
[Image of KREM Door logo]  
[Image of KREM Cameras logo]  
[Image of KREM Ejector logo]  
[Image of KRUPS Activation logo]  
[Image of GSE 1/2 Total logo]  
[Image of TE1/2/3/R Total logo]  
[Image of Total logo]  
[Image of Total Power Capacity logo]  
[Image of Over/Under logo]  
[Image of # of Flights Margin logo]  
[Image of COSGC logo]  
[Image of ROCKSAT-X logo]  
[Image of WFF logo]  

CDR 2014
4.0 Prototyping/Analysis Results/Plans

*Tyler Nichols*
Prototyping Results/Plan

• KOREVET and KUDOS
  • Internal Housing
  • Thermoplug
  • TPS
  • KREM

• Findings:
  • Successful deployment of capsule on previous sounding rocket flights for a sub-scale and full-scale vehicle
  • Ability to establish connection via the Iridium Satellite Network
  • KREM is able to integrate within provided constraints
  • Not able to collect Data
  • Need for more reliable activation
Prototyping Results/Plan

• Plans
  – Currently awaiting new internal housing 3-D print
  – Currently awaiting parachute
  – Currently awaiting sensors and internal electronics

• These items will be used to verify all capsule components are able to function as designed and can be integrated within the capsule.
Analysis Results/Plans

• Finite Element Analysis
  – Deformation of TPS
  – Stress and deformation on electronic dead bolt pin
  – Stress and deformation experienced by PRED components during maximum opening forces
  – Stress and deformation on housing during impact and parachute opening forces

• Key results
  – TPS will not be deformed due to solenoid arm or the 25 and 50 G’s during launch
  – Dead bolt pin will not experience stress or deformation that will cause the door not to open
  – Internal housing will not deform or fail during impact or when experiencing parachute opening forces.
  – PRED components will not fail due to maximum opening forces
Analysis Results/Plans

- Plans for other analysis
  - Further stress and deformation analysis on internal housing to ensure survival upon splashdown and during parachute deployment
  - Analysis on housing with electrical components inside to ensure these components will function as designed after experiencing splashdown forces
5.0 Manufacturing Plan

Collin Dietz and Tyler Nichols
Mechanical Elements

• KREM
  – Manufactured
    • Plates: Waterjet by external source (currently underway)
    • Filler Material: CNC milled in house (currently underway)
    • Brackets: machined in house (currently underway)
  – Purchased
    • Solenoids
    • Fasteners
    • Vibration Isolators
Mechanical Elements

• Capsule
  – Manufactured
    • TPS: CNC milled in house (currently underway)
    • Internal Housing: 3D printed by ProtoLabs (currently underway)
    • Thermoplug: CNC milled in house (currently underway)
    • Electronics Support: manufactured in house
  – Purchased
    • Fasteners
Electrical Elements

• To Be Manufactured
  – PCB must be ordered and reflow soldered

• Number of Revisions
  – Anticipate a new build every 2-3 months to improve stability and issues

• What needs to be procured?
  – Iridium Modem, ISM Radio and all PCB components

• Plan to begin ordering parts as soon as first revision is finalized and have board completed 1 month before integration
Software Elements

• What discrete blocks of code need to be completed?
  – ISM Radio control

• Code in current needs is written and tested, will be tested and validated as electrical systems are tested
6.0 Testing Plan

Collin Dietz and Tyler Nichols
Testing Plan: Mechanical Testing

• **Weight of Overall System**  
  • Weigh the individual and overall system using a scale  
  • Projected timeline is January

• **Center of Gravity**  
  • Finding the balance point on angle brackets  
  • Projected timeline is January

• **Vibration testing**  
  • Shaker test  
  • Projected timeline is February

• **Thermal plug scan**  
  • X-ray the plugs and TPS to verify location of thermocouples  
  • Projected timeline is February

• **Impact Testing**  
  • Conduct splashdown to ensure all components can survive splashdown and continue to function as designed  
  • Projected timeline is April
Testing Plan: Mechanical Testing

- **Waterproof Testing**
  - Ensure internal compartment of capsule is able to remain watertight after splashdown
  - Projected timeline is April

- **Parachute Deployment Test**
  - Ensure parachute is able to deploy and slow capsule descent to a desired margin
  - Projected timeline is April

- **Dynamic Pressure Test**
  - Ensure parachute is able to deploy as the desired pressure and velocity determined at the desired deployment altitude
  - Projected timeline is April
Testing Plan: Electrical Testing

• Validation of PCB Build
  • Test via pre made test code for each component
  • Evaluated every build

• Validation of Communication Systems
  • Test via dummy data communication tests
  • Test via High Altitude Balloon Flights
  • Evaluate upon modem/radio delivery

• Validation of Sensors
  • Test via expected baseline readings
  • Evaluated every build

• Validation of KREM Electronics
  • Test via In-house GSE Test system
  • Test via Sequence Testing
  • Evaluated after initial build and during regular system tests
Testing Plan: Software Testing

- Current iteration of code is heavily tested both on ground and through 2 flights
- Expected output and data through-put is tested every run of hardware
- New revisions of code will be tested and relevant hardware pieces are added/extended
- Unit Tests may be added for decoupled testing if possible
Testing Plan: System Level Testing

- Full Sequence Testing is possible via an In-House GSE system
  - Tests both the Mechanical systems and Electrical systems of KREM simultaneously
  - Communication systems can be tested by moving tests outdoors
  - Decoupling the capsule from KREM allows testing of every system simultaneously
- Will be evaluated as soon as all builds allow, and then regularly as new components are added
7.0 User Guide Compliance

Collin Dietz
## 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>Within 1”</td>
</tr>
<tr>
<td>Weight 30.0 +/- 1.0 (15.0 +/- 0.5) lbs?</td>
<td>31 lbs currently</td>
</tr>
<tr>
<td>Max Height &lt; 10.75” (5.13”)</td>
<td>Design for 13.125-inches</td>
</tr>
<tr>
<td>Bottom of deck has flush mount hardware?</td>
<td>YES</td>
</tr>
<tr>
<td>Within Keep-Out Zone</td>
<td>YES</td>
</tr>
<tr>
<td>Using &lt; 10 A/D Lines</td>
<td>Currently N/A</td>
</tr>
<tr>
<td>Using/Understand Parallel Line</td>
<td>Currently N/A</td>
</tr>
<tr>
<td>Using/Understand Asynchronous Line</td>
<td>Currently N/A</td>
</tr>
<tr>
<td>Using X GSE Line(s)</td>
<td>Currently N/A</td>
</tr>
<tr>
<td>Using X Non-Redundant PWR Lines (TE-1, TE-2, TE-3)</td>
<td>YES</td>
</tr>
<tr>
<td>Using X Redundant Power Lines (TE-R)</td>
<td>Currently N/A</td>
</tr>
<tr>
<td>Using &lt; 1 Ah</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, Frequency 915 and 1616-1626.5 MHz. Only TX on ejected capsule. Potential for additional.</td>
</tr>
<tr>
<td>Using deployable?</td>
<td>YES</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>
### User Guide Compliance: Power Interface

<table>
<thead>
<tr>
<th>Power Pin</th>
<th>Function</th>
<th>Intended Use</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>GSE 1</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>Timer Event Redundant (TE-RA)</td>
<td>N/A</td>
</tr>
<tr>
<td>3</td>
<td>Timer Event Redundant (TE-RB)</td>
<td>N/A</td>
</tr>
<tr>
<td>4</td>
<td>Timer Event 1 (TE-1)</td>
<td>Activate Cameras</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td>GND</td>
</tr>
<tr>
<td>6</td>
<td>GND</td>
<td>GND</td>
</tr>
<tr>
<td>7</td>
<td>GND</td>
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</tr>
<tr>
<td>8</td>
<td>GND</td>
<td>GND</td>
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<tr>
<td>9</td>
<td>GSE 2</td>
<td>N/A</td>
</tr>
<tr>
<td>10</td>
<td>Timer Event 2 (TE-2)</td>
<td>Open Door, Activate Capsule</td>
</tr>
<tr>
<td>11</td>
<td>Timer Event 3 (TE-3)</td>
<td>Eject Capsule</td>
</tr>
<tr>
<td>12</td>
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<td>GND</td>
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<tr>
<td>13</td>
<td>GND</td>
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<tr>
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</tr>
<tr>
<td>15</td>
<td>GND</td>
<td>GND</td>
</tr>
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</table>
User Guide Compliance: Telemetry Interface

No current intentions to utilize telemetry connections.

<table>
<thead>
<tr>
<th>Telemetry Connector--Customer Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
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</tr>
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<td>18</td>
</tr>
<tr>
<td>19</td>
</tr>
</tbody>
</table>
8.0 Project Management Plan (PMP)

Tyler Nichols
PMP: Management

Faculty Advisors

Dr. Bill Smith
Dr. Alexandre Martin
Dr. Suzane Smith

Team Leads

Collin Dietz
Tyler Nichols

Sub Teams

Software Team
EE Capstone Team
ME Production Team
ME Capstone Team
PMP: Budget/Schedule

• Preliminary Budget: $50,000
• Schedule
  – Winter Break
    • Machine and assemble KREM (December 2018)
    • Machine TPS and thermoplug (December 2018)
    • Finalize Activation and Communication (December 2018)
    • Finalize all order for KREM and capsule components
  – Next Semester
    • Test Parachute
    • Test electrical design
    • Order internal housing
    • Machine and assemble KRUPS capsule
    • Run all mechanical tests on capsule (vibe, center of gravity, splashdown)
    • Conduct full simulation tests
# PMP: Latest Contact Matrix

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<tr>
<th>University of Kentucky</th>
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<td>Role</td>
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<td>Core team</td>
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PMP: Worries

• Communication failure
  – Evaluation of the communication system is being conducted by a team advised by individuals who specialize in communication
  – Consultation from NASA experts who design communication systems for sounding rocket flights
  – A high altitude balloon launch will be conducted to test the antennas and software at high altitude

• Activation failure
  – Evaluation and redesign of the activation system is being conducted to mitigate failure
  – A high altitude balloon launch will be able to test the activation at high altitude
PMP: Conclusions

• This mission is a cost effective method of validating numerical models and experimental ground tests by direct comparison with flight data. This will result in improved design of Thermal Protection Systems. The mission will also increase the TRL of the vehicle to TRL 7 to allow for possible future orbital flight.

• Next steps toward the STR
  – Finalize communications and activation design
  – Finalize prototypes
  – Begin constructing KREM and capsule
  – Prepare for high altitude balloon launch