SCAMP II
Critical Design Review

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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
Mission Overview: Mission Statement

- SCAMP II (Space Characterization and Assessment of Manipulator Performance II)
- Fly functional robotic manipulator components in a microgravity environment
- Determine effects of microgravity on drivetrain components and resulting performance changes
Mission Overview: Mission Objectives

• Actuate through a ~1.5 minute, increasing amplitude sine wave motion to determine robotic mobility dynamics

• Test contact performance
  – Compliant/non-compliant, potential mutual contact
  – Roughly 45 seconds on each contact

• Collect acceleration, loading, current, and encoder count data at minimum, with full video

• Minimum success criteria
  – Data against one contact and a picture of one of the actuators
• The characterization of a robotic manipulator’s dynamic characteristics, especially while encountering impeded movement, are of great importance to the future development of more intelligently designed systems.
  – SCAMP provides powerful insight to this area in specific related to DYMAFLEX
• NASA Goddard Space Flight Center is also interested in the variance of inertial loads on the end-effector
## ConOps Timeline

<table>
<thead>
<tr>
<th>Time</th>
<th><strong>Robot 1</strong></th>
<th><strong>Robot 2</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>T+045</td>
<td>Microgravity starts; Motors powered on Sine sweep starts</td>
<td>Microgravity starts; Motors powered on Contact testing</td>
</tr>
<tr>
<td>T+135</td>
<td>Contact testing</td>
<td>Sine sweep</td>
</tr>
<tr>
<td>T+225</td>
<td>Robot moves to eject position</td>
<td>Robot moves to eject position</td>
</tr>
<tr>
<td>T+240</td>
<td>ejects mass</td>
<td>ejects mass</td>
</tr>
<tr>
<td>T+255</td>
<td>Sine sweep</td>
<td>Sine sweep</td>
</tr>
<tr>
<td>T+345 (actually 332)</td>
<td>Poweroff</td>
<td>Poweroff</td>
</tr>
</tbody>
</table>
## Concept of Operations: GSE/TE Line Callout

<table>
<thead>
<tr>
<th>Event</th>
<th>Time On</th>
<th>Dwell</th>
<th>Event Description</th>
</tr>
</thead>
</table>
| GSE 1  | T-180 sec| 540 sec| Maximum time before launch (3+ minutes)
|        |          |        | Logic system powers on; boots                                                     |
| TE-1   | T+045 sec| 290 sec| Burn complete, now in free-fall. Activate motors.
|        |          |        | Motors remain on for remaining time                                               |
| TE-2   | T+240 sec| 15 sec | Mass ejection                                                                      |
Mission Overview: Expected Results

• Determine radial stability (i.e. no oscillatory motion) when manipulator has different resistive forces impeding movement, and to what extent this can be accounted for and measured with a sensor suite/code

• Determine the dynamic parameters of a motor under 2 different moments of inertia of the end effector, while in absence of gravity pre-loading on the drivetrain.
Mission Overview: Success Criteria

**Minimum Success Criteria:**
- Force, current, and encoder data from one manipulator against one of the contacts

**Comprehensive Success Criteria:**
- Load Cell data for both arms throughout the entire testing period
- Video capture from multiple perspectives of each end effector
- Full encoder data from each end effector
- Full 3-phase current from both motors for all time
- Accelerometer data from both motors for all time
## Top Level Requirements:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>The manipulator must be able to home itself successfully/use an absolute encoder to prevent homing failure</td>
<td><strong>Demonstration</strong></td>
<td>Throughout testing in our thermal vacuum chamber as well as on bench testing of our currently existing manipulator.</td>
</tr>
<tr>
<td>The mass must be ejectable at some recommended safe velocity</td>
<td><strong>Analysis</strong></td>
<td>Utilizing dynamics equations and selecting release mechanisms and materials that allow these equations to be a realistic and accurate modeling</td>
</tr>
<tr>
<td>The full assembly must be no greater than 5” in height</td>
<td><strong>Inspection</strong></td>
<td>Visual inspection will verify this requirement (and CAD).</td>
</tr>
<tr>
<td>With the mass on the end effector, the harmonic drive must not pull out such as it did in vibration testing in June 2018</td>
<td><strong>Test</strong></td>
<td>The addition we made post-integration greatly improved the structural integrity of the end effector, and we can use the testing at integration as well as testing of forces generated by the acceleration during the assembly.</td>
</tr>
</tbody>
</table>
2.0 System Overview
System Overview: Science Design Overview

- Data from microgravity experiment can be compared to on-earth tests to determine effects of gravity pre-loading
- All data processing is done post-flight
  - Arm force, arm acceleration, motor current and position all logged simultaneously during flight
- Variable Moment of Inertia allows for generalization to different manipulators
- Camera provides engineering data
System Overview: Science Design Diagram

SCAMP Science Layout Legend

<table>
<thead>
<tr>
<th>Power Board</th>
<th>Tweeter Carrier</th>
<th>PocketBeagle Carrier</th>
<th>Rocket</th>
<th>ADC sled</th>
<th>Exterior</th>
</tr>
</thead>
</table>

Diagram showing various components and connections:
- IMU
- Load Cell
- Current sensors
- Encoder
- Electable mass
- RS232 telemetry
- CAN/Digital
- Analog
- I2C
- UART
- USB
- Control PocketBeagle
- ItsyBitsy M4
- Camera PocketBeagle
- SD card
- FOV connections
System Overview: Science Design Data/Results

• **Load cell/IMU**
  - control loop performance (detectable vibrations)

• **Encoder + current sensor data**
  - Motor+drivetrain internal friction result

• **Encoder + load cell data**
  - Motor+drivetrain spring constant result

• **Encoder+IMU data**
  - Detect inertial effects during motion
  - Detect higher-frequency vibrations
Systems Overview: System Changes Since PDR

• Added second Pocketbeagle
  – Offloads camera from control pocketbeagle
  – Adds to power consumption
• ADC sled moved to its own “slot” in electronics housing
System Overview: Top-Level FBD
System Overview: Data Flow (Science Design)
System Overview: Power/Data Flow
System Overview: Rocket Connection/Inhibit

SCAMP Rocket Connection Legend

<table>
<thead>
<tr>
<th>Power Board</th>
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</tr>
</tbody>
</table>

Diagram:

- **TE-1**
  - 28V TE-1
  - Tweeter
    - Motor Drive
  - Logic systems
    - 5V command

- **GSE-1**
  - 28V GSE
  - Power board
    - 5V

- **Async. Telemetry**

- **TE-2**
  - 28V TE-2
  - Mass release inhibit (connector)
    - 28V
  - Mass release

2019 CDR
System Overview: Mechanical Design

- Actuator design is identical to last year’s flight proven manipulator
  - End-effector undergoing changes for accommodation of new mass ejection
  - Soft contact redesigned to be easier to manufacture and be more reliable
  - Machined from Al6061
System Overview: Mechanical Design
System Overview: Mechanical Design
System Overview: Mechanical Design
System Overview: Electrical Design

• Setup based on providing custom breakout boards for COTS components
  - Complex parts: Pocketbeagle, Tweeter, ItsyBitsy and SMPS all bought COTS, to reduce development time
  - Each large COTS parts has a custom breakout board which provides electrical and mechanical interfaces.

• Overall diagram shown in FBD section
  - Board-level diagrams shown in subsystem section
All rocket grounds are assumed to be common
  - This introduces Lots of locations for ground loops
  - Design uses isolated power supplies and digital isolators to break ground loops
All logic powered from single GSE
All motors powered from single TE line
  - It would be nice to have 2 TE lines
System Overview: Software Design

• Written mostly in C++
  - Main control software runs control loops for motor, and switches through a series of steps after executing them for a certain time

• Camera software runs continuously, recording footage

• ADC software runs continuously
  - may get some interesting back-emf results while motors are unpowered during launch
System Overview: Software Design

USB Camera

FFMPEG

SDCard

PocketBeagle boot

Wait for TE line to activate

Home motor

Start motor
Sine/Contact

Switch to other task

TE-2

Move to eject position

Sine sweep

Save/Shutdown

ADC

Custom SPI ADC interface

SD card
System Overview: Description of Partnerships

- Project is funded through Maryland Space Grant
- NASA Goddard Space Flight Center has interest in the data, but they are not providing any assistance with design or fabrication
De-Scopes

• Downlink data rate too small for amount of minimum data we try to send
  – Solution: Downsample data points generated for telemetry or send down single sine sweep
• Not all camera locations are viable for camera size (when chosen)
  – Solution: Downsize number of cameras per end-effector
• If an absolute encoder cannot be added to design
  – Solution: Utilize a similar homing sequence to 2018, but with more error handling and further testing.
System Overview: Special Requests

• Mass ejection
  - Both manipulators will be ejecting a ~100g mass mid-way through the test
  - 1 in/s
  - Pointed away from rocket structure

• 3 small supercapacitors to run RTC’s onboard
  - Technically not batteries, but do carry energy
  - Voltage is very low: Vmax<2.7V
  - Capacitance 0.22F
Pointing Request: N/A
3.0 Subsystem Design
Subsystem Design

- Robot Arm
- Science
- PocketBeagle+Carrier
- Tweeter+Carrier
- PocketBeagle + Camera
- ADC sled
- Power Board
- Software
Subsystem Design: Drivetrain Design (Robot Arm)

- Harmonic Drive (Gearbox)
- Motor
- Driveshaft Anchor
- Driveshaft
- Wire and Encoder Area
- Inner Drive Plate (Dynamic)
- Outer Housings (Static)
Subsystem Design: Motor Wire Entry (Robot Arm)

Wire passthrough
Subsystem Design: Machined parts (Robot Arm)
RSK.1: Mission objectives aren’t met if Harmonic Drive slips during launch loads
RSK.2: MOI objectives aren’t met if mass fails to eject
RSK.3 If o-ring failure occurs during flight waterproofing is compromised and actuator becomes unusable
Subsystem Design: Science

- Partially driven by DYMAFLEX design
  - encoder is legacy DYMAFLEX encoder
- Load cell needs to measure 10lbs of force, with excitation voltage of 5-7V
  - Still looking at options, most small parallel beam load cells are unidirectional
- IMU is Sparkfun MPU-S250 breakout
- Current sensors need to measure high-frequency current
  - GMR contactless sensors, 1GHz bandwidth
Subsystem Design: Science

Rotary Encoder
Subsystem Design: Science

Ejectable Mass

Load Cell
Subsystem Design: Science
RSK.1: Mission fails if a data-logging issue occurs
RSK.2: Partial mission failure if load cell fails due to launch loads/vacuum
RSK.3: No video data if camera subsystem fails
RSK.4 Partial failure if load cell fails during mutual contact ops.
Subsystem Design: PocketBeagle+Carrier

• Carries main flight computer
  – Weight: 0.062 lb
  – Contains communication IC’s for RS232 and CAN
  – Features digital isolators
  – 24-bit ADC with PGA frontend for load cell measurement.

• Current board is flight-ready, but new revision is being developed to mitigate known issues
Subsystem Design: PocketBeagle

- **Main flight computer**
  - 1GHz ARM processor
  - 512MB RAM
  - integrated CAN MAC
  - integrated SPI/I2C lines
  - onboard SD card slot for OS and data
- **Runs Debian Linux**
- **COTS**
- **Package heat-sinks into electronics box chassis**
Subsystem Design: PocketBeagle+Carrier

[Diagram of PocketBeagle+Carrier subsystems with labels such as Load cell, RC filter, ADC/PGA, Analog Supply, Programming USB (integrated), Main 5V Supply, Telemetry Supply, Rocket Telemetry, Serial +/-6V Charge pump, Digital Isolator, Galvanic Isolation, and other components like CAN Bus, CAN Tranceiver, USB, SPI, UART Driver, GPIO, SD Interface, IMU (2X), SD card (integrated), and exterior parts like Power Board, Tweeter Carrier, PocketBeagle Carrier, Rocket, ADC sled, and Exterior.]
RSK.1: Mission fails if pocketbeagle fails
RSK.2: Downlink fails if any part of RS232 subsystem fails
RSK.3: Single-event power upset in main C&DH system
Subsystem Design: Tweeter+Carrier

- Carries Tweeter motor driver
  - Weight: 0.081lb
  - Integrated GMR contactless current sensors
  - Encoder line driver,
  - Programming header
- Design is flight-ready, some changes would be nice to clean up connectors
Subsystem Design: Tweeter

• CAN-controlled 3-phase brushless DC motor driver with encoder feedback.
  – features advanced command list
  – Supports motor current limiting
  – Motor power separate from logic power

• COTS

• Heat-sinks power transistors through electronics chassis
Subsystem Design: Tweeter+Carrier

Diagram of subsystem design with various components connected, including:
- Rocket 28V GSE
- CANBus
- Capacitive filter
- Programming header
- Tweeter Logic
- Line driver
- Indicator LED
- Hall sensors
- Motor
- Encoder
- SHUNTS
  - ISO
  - Contactless GMR current sensors (X3)
- ADC sled

SCAMP Tweeter Carrier Legend:

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</tbody>
</table>

2019 CDR
Risk Matrix: Tweeter+Carrier

RSK.1: Mission Failure due to overcurrent
RSK.2: Mission Failure due to CANBus lockout
Subsystem Design: PocketBeagle + Camera

- System breaks out camera from main pocketbeagle, lessening system load
  - System is completely independent from all others (sans power)
  - Carrier board holds only USB connector and power input

- System design is final
  - PCB needs to be created
Risk Matrix: PocketBeagle+Camera

RSK.1: No video data due to failure
RSK.2: No video data due to camera failing in vacuum
Subsystem Design: ADC sled

• Performs high-speed current sampling of motor phases
  – 3 channel, 14 bit, 250k sample/sec/channel ADC
  – Powered by SAMD51, with SD card for logging
• Analog data comes from 1GHz bandwidth GMR sensors on Tweeter Carrier.
• Weight: 0.025 lb
• System not final - needs to be tested, and connectors need improvement
Subsystem Design: ADC sled

- Main 5V Supply
- Programming USB (integrated)
- ADC bypass
- RC Low-pass filter $f_{co} = 66$MHz
- GMR sensors
- SD card
- ItsyBitsy M4
  - SPI
  - ADC
  - GPIO
  - SPI
  - I2C
- Clock Sync
- IMU
- RTC
- Supercap

**SCAMP PocketBeagle Carrier Legend**
- Power Board
- Tweeter Carrier
- PocketBeagle Carrier
- Rocket
- ADC sled
- Exterior
Risk Matrix: ADC Sled

RSK.1: RTC supercap back-feeds in to electrical system
RSK.2: ItsyBitsy can’t handle 50MHz SPI data bus + SD writes
RSK.3: Analog data corrupted due to interference
Subsystem Design: Power Board

- Supplies isolated power to all logic systems, sans Tweeter
  - **Weight:** 0.068
  - Steps down 24-32V to 5V using isolating SMPS
  - Runs from GSE line, allowing for logic system to boot before launch

- Heat sink to electronics box chassis

- Final!
Subsystem Design: Power Board
RSK.1: Mission fails if logic power supply fails
RSK.2: Mission fails if motors draw too much power
RSK.3: Incomplete date acquisition if aux. power supplies fail
Subsystem Design: Software

- Software written in C++
  - Current focus of development.
- Using CANFestival for CAN interface
- Using FFMPEG for video capture
  - Bash script as glue code
- All systems start via systemd, with automatic crash recovery
Risk Matrix: (Software)

RSK.1: Experiment time cut short by logic Software crash
RSK.2: Mission failure due to OS crash
Subsystem Design: Detailed Weight Budget

- 6.803 +/- 0.227 kg
- Weight of payload deck is 1.55 kg

<table>
<thead>
<tr>
<th>Item (x2):</th>
<th>Mass (g):</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBC</td>
<td>28.5</td>
</tr>
<tr>
<td>TW</td>
<td>37</td>
</tr>
<tr>
<td>PDB</td>
<td>31</td>
</tr>
<tr>
<td>ADC</td>
<td>11.5</td>
</tr>
<tr>
<td>PBC 2</td>
<td>28.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item (need x2):</th>
<th>Mass (g):</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-box</td>
<td>682.5</td>
</tr>
<tr>
<td>Arm</td>
<td>1290</td>
</tr>
<tr>
<td>Stops</td>
<td>124</td>
</tr>
<tr>
<td>Camera</td>
<td>198</td>
</tr>
<tr>
<td>Total (x2 col):</td>
<td>4588</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item:</th>
<th>Mass:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int. wire:</td>
<td>114</td>
</tr>
<tr>
<td>Ext. wire</td>
<td>37.5</td>
</tr>
<tr>
<td>Plate</td>
<td>1550</td>
</tr>
<tr>
<td>Total:</td>
<td>6562.5</td>
</tr>
<tr>
<td>Delta:</td>
<td>-.2405</td>
</tr>
</tbody>
</table>
### Subsystem Design: Detailed Power Budget

- Note: Power for Pocketbeagle and Tweeter measured at rocket power source.
  - This accounts for all system inefficiencies, and measures the actual load the rocket will see
  - Camera Pocketbeagle and ADC sled power are estimates
    - ADC sled power converted to 28V equivalent to have the chart work nicer
- All power supplies are isolating SMPS, so power is conserved during step-down
  - i.e Pocketbeagle draws ~600ma at 5V, but rocket only has to provide ~100 ma

<table>
<thead>
<tr>
<th>Wallops Power Line</th>
<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>GSE1</td>
<td>Tweeter (measured)</td>
<td>28.0</td>
<td>0.07</td>
<td>-3</td>
<td>8</td>
<td>2.07</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Main Pocketbeagle (measured)</td>
<td>28.0</td>
<td>0.12</td>
<td>-3</td>
<td>8</td>
<td>3.36</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>Camera Pocketbeagle (est.)</td>
<td>28.0</td>
<td>0.12</td>
<td>-3</td>
<td>8</td>
<td>3.36</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>ADC sled (est.)</td>
<td>28.0</td>
<td>0.09</td>
<td>-3</td>
<td>8</td>
<td>2.52</td>
<td>0.01</td>
</tr>
<tr>
<td>TE1</td>
<td>Motors</td>
<td>28.0</td>
<td>3.00</td>
<td>0.75</td>
<td>5</td>
<td>84.00</td>
<td>0.25</td>
</tr>
<tr>
<td>TE2</td>
<td>Release</td>
<td>28.0</td>
<td>0.25</td>
<td>4</td>
<td>0.25</td>
<td>7.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

|                  |                      |             |                 |                  |              |       |     |
|                  | GSE 1/2 Total        | 0.404       |                 |                  |              |       |     |
|                  | TE1/2/3/R Total      | 3.25        |                 |                  |              |       |     |
|                  | Total                | 3.65        |                 | 102.31           | 0.30         |       |     |
|                  | Total Power Capacity |             |                 |                  |              | 0.50  |     |
|                  | Over/Under           |             |                 |                  |              | 0.20  |     |

# of Flights Margin: 1.6
4.0 Prototyping/Analysis Results/Pans
Prototyping Results/Plan

- **2018 flight**
  - Actuator survived launch loads and showed water-proofing success

- **2019**
  - Manufacturing to begin in January for second actuator, as well as prototyping for new soft-contacts, and larger electronics box
Analysis Results/Plans

- Sealing mechanism verified
- Actuator alignment maintained through flight and recovery
- Actuator design structure can be remanufactured to spec for 2019 (DYMAFLEX design)
Electronics testing

- Boards worked during 2018 flight
  - Few changes are being made
- 2018 flight boards are currently being used as development platform
- ADC sled pending testing
- Verified RS232 telemetry compliance
Software testing

- CANFestival code builds on pocketbeagle
- CANFestival finds CAN interface on pocketbeagle
- CANfestival sample code communicates with CANBus
  - Confirmed via candump utilities, actual external CANbus is being written to.
5.0 Manufacturing Plan
Mechanical Elements

- Camera mounts, another actuator, new end-effectors, contacts, as well as electronics boxes are manufactured in-house
- Cameras and load-cell intend to be purchased
Electrical Elements

- New boards:
  - Pocketbeagle Carrier (design done, needs routing)
  - ADC sled (needs connector re-work)
  - Tweeter Carrier (needs connector re-work)
  - Pocketbeagle Camera (needs routing)

- Boards expected to be ordered by late January.

- New board assembly+test scheduled for February.
Electrical Elements

- New board revisions should go out again late February, if needed.
- Flight-like boards should be assembled by end of March, so that integration testing can begin.
Software Elements

• CANFestival code needs to be adapted to run the robot
  - Sample code exists, but is poorly documented
• Code needs to be written for the camera system
  - Similar code was used for 2018, but there will be serious changes to ensure robustness
Software Elements

- CANfestival code expected to be minimally functional by late February
- Code to be integrated with ADC code in March, with functionality improvements to follow
- Camera code to be completed by end of January, so that camera testing can begin before design becomes too fixed.
6.0 Testing Plan
Test/Prototyping Plan

- Vacuum Part Testing
  - Independent part to be tested to make sure launch or vacuum issues
- Vacuum manipulator movement testing
  - Test fully assembled and sealed actuator in thermal vacuum chamber to ensure full functionality
- Thermal Testing
  - Test endurance expected thermal swings between launch and end of experiment
- All tests can be done in-house with facilities available to students and lab members
Testing Plan: Electrical Testing

- Current electronics are being used by software development platform
  - Testing is complete for existing boards, and new boards are not yet in-hand.
  - Will need to re-verify CAN/SPI/I2C for new PocketBeagle Carrier
- Need to test supercapacitor powered RTC
- No high voltages
- Mass ejection inhibit via a single connector
Testing Plan: Electrical Testing

• ADC sled still needs to be tested
  – Waiting on software
  – Will be tested by recording motor current while testing main control software
  – Confirm 250k/sample/sec/channel data capability (does the 50MHz SPI bus work?)

• Camera PocketBeagle
  – Test if USB works
Testing Plan: Software Testing

• Test if CANFestival forced PDO transmission works
  – attempt to command Tweeter motor controller
• Test if FFMEG video capture works
  – Run camera PocketBeagle through full mission sim, and view video logged to SD card
• No software inhibits
  – All inhibits are in software
Testing Plan: System Level Testing

• Scientific data requires pre-flight testing and logging of data under gravity pre-loaded conditions
  ○ Provides multitude of opportunities for full system tests and verification between integration and launch
• Each actuator tested/functions independently
7.0 User Guide Compliance
# 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&quot; (5.13&quot;)</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>YES</td>
</tr>
<tr>
<td>Using &lt; 10 A/D Lines</td>
<td>NOT USING</td>
</tr>
<tr>
<td>Using/Understand Parallel Line</td>
<td>NOT USING</td>
</tr>
<tr>
<td>Using/Understand Asynchronous Line</td>
<td>YES</td>
</tr>
<tr>
<td>Using X GSE Line(s)</td>
<td>YES, GSE 1</td>
</tr>
<tr>
<td>Using X Non-Redundant PWR Lines (TE-1, TE-2, TE-3)</td>
<td>YES Using TE-1 and TE-2</td>
</tr>
<tr>
<td>Using X Redundant Power Lines (TE-R)</td>
<td>NOT USING</td>
</tr>
<tr>
<td>Using &lt; 0.5 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>NO</td>
</tr>
<tr>
<td>Using deployable?</td>
<td>Yes (clarification/approval needed)</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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### Power Connector--Customer Side

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
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<tbody>
<tr>
<td>1</td>
<td>Logic Power</td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Motor Power</td>
</tr>
<tr>
<td>5</td>
<td>Motor GND</td>
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<tr>
<td>6</td>
<td>Motor GND</td>
</tr>
<tr>
<td>7</td>
<td>Logic GND</td>
</tr>
<tr>
<td>8</td>
<td>Logic GND</td>
</tr>
<tr>
<td>9</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Mass Eject</td>
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<td></td>
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<td></td>
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- Blank pins unused
User Guide Compliance: Telemetry Interface

<table>
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<th>Telemetry Connector--Customer Side</th>
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<td>Function</td>
</tr>
<tr>
<td>1</td>
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<tr>
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<tr>
<td>5</td>
<td>24</td>
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</tr>
<tr>
<td>6</td>
<td>25</td>
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<tr>
<td>7</td>
<td>26</td>
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<tr>
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<tr>
<td>12</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>32</td>
<td>Telemetry down</td>
</tr>
<tr>
<td>14</td>
<td>33</td>
<td>Telemetry GND</td>
</tr>
<tr>
<td>15</td>
<td>34</td>
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</tr>
<tr>
<td>16</td>
<td>35</td>
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<td>19</td>
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</tbody>
</table>

- Blank pins unused
User Guide Compliance: Telemetry Interface
8.0 Project Management Plan (PMP)
Management – Organization Chart

Dr. Akin and Dr. Bowden (P.I.’s)

Software:
- Daniil Gribok

Design Guidance
- Nicholas Limparis

Hardware:
- Charlie Hanner
# Management – Monetary Budget

## RockSatX 2018 Budget Summary - UMCP

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Launch Cost (Paid to Univ of Colorado)</strong></td>
<td></td>
</tr>
<tr>
<td>Earnest Deposit (due in October)</td>
<td>$2,000</td>
</tr>
<tr>
<td>First Installment (due in February)</td>
<td>$6,000</td>
</tr>
<tr>
<td>Final Installment (due in April)</td>
<td>$6,000</td>
</tr>
<tr>
<td><strong>Total Launch Cost</strong></td>
<td><strong>$14,000</strong></td>
</tr>
<tr>
<td><strong>Payload Supplies for SCAMP (Dr. Akin)</strong></td>
<td></td>
</tr>
<tr>
<td>Electronics (sensors, loggers, controllers, batteries)</td>
<td>$2,000</td>
</tr>
<tr>
<td>Mechanical Components for SCAMP</td>
<td>$2,500</td>
</tr>
<tr>
<td><strong>Total Support Supplies</strong></td>
<td><strong>$4,500</strong></td>
</tr>
<tr>
<td><strong>RockSatX Travel Costs</strong></td>
<td></td>
</tr>
<tr>
<td>Travel to Wallops for Integration Week</td>
<td>$400</td>
</tr>
<tr>
<td>Hotel for Integration Week (1 room x 6 nights)</td>
<td>$750</td>
</tr>
<tr>
<td>Travel to Wallops for Launch Week</td>
<td>$800</td>
</tr>
<tr>
<td>Hotel for Launch Week (1 x 7 nights + 1 x 2 nights)</td>
<td>$1,150</td>
</tr>
<tr>
<td><strong>Total Travel Costs</strong></td>
<td><strong>$3,100</strong></td>
</tr>
<tr>
<td><strong>Salaries for selected RSX Students</strong></td>
<td></td>
</tr>
<tr>
<td>500 hours of part-time undergraduate effort@$10/hr</td>
<td>$5,000</td>
</tr>
<tr>
<td><strong>Total Student Salaries</strong></td>
<td><strong>$5,000</strong></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$26,600</strong></td>
</tr>
</tbody>
</table>
## Management – Contact Matrix

### Fall 2018 RS-X 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>PI</td>
<td>David Akin</td>
<td>301-405-7353</td>
<td>410-491-2225</td>
<td>No</td>
<td><a href="mailto:rocksatx@ssl.umd.edu">rocksatx@ssl.umd.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Advising Professor</td>
<td>Mary Bodwin</td>
<td>301-405-0011</td>
<td></td>
<td>No</td>
<td><a href="mailto:rocksatx@ssl.umd.edu">rocksatx@ssl.umd.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Advisor</td>
<td>Nicholas Limparis</td>
<td>301-405-7353</td>
<td></td>
<td>No</td>
<td><a href="mailto:rocksatx@ssl.umd.edu">rocksatx@ssl.umd.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Electronics</td>
<td>Danil Gribok</td>
<td>301-405-7353</td>
<td></td>
<td>No</td>
<td><a href="mailto:rocksatx@ssl.umd.edu">rocksatx@ssl.umd.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Hardware</td>
<td>Charlie Hanner</td>
<td>301-405-7353</td>
<td>301-401-8787</td>
<td>Yes</td>
<td><a href="mailto:channer@ssl.umd.edu">channer@ssl.umd.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
</tbody>
</table>
PMP: Worries

• Mass ejection mechanism
  - Only semi-complex mechanical system untested on payload currently
  - Detailed design is underway, with future testing necessary for verification
  - Current plan utilizes a threaded mass, acme threaded rod, and motor for “simple” deployment

• Mass ejection: Clarify TE-line requirement

• Supercapacitor - concerns from wallops?
Conclusion

• The SCMAP mission provides valuable data to both SSL and NASA Goddard
  – Data will help advance the state-of-the-art of space servicing vehicles, which have just started to enter concept and design phases.