CDR Agenda
(Topics to be covered)

• Section 1: Mission Overview
  • Mission Statement
  • Mission Objectives
  • Theory and Concepts
  • Concept of Operations
  • Mission Timeline
  • Expected Results
  • Success Criteria
  • Top Level Requirements
CDR Agenda
(Topics to be covered)

• Section 2: System Overview
  • Science Design Overview (UMCP STAR Experiment)
  • System Changes
  • Functional Block Diagram
  • Mechanical Design
  • Electrical Design
  • Software Design
  • Description of Partnerships
  • De-Scopes and Off-Ramps
  • Special Requests
CDR Agenda
(Topics to be covered)

• Section 3: Subsystem Design
  • Subsystem Details
  • Risk Matrices
  • Detailed Weight Budget
  • Detailed Power Budget

• Section 4: Prototyping/Analysis and Testing Plan
  • Prototyping Results / Plan
  • Analysis Results / Plan
  • Mechanical Testing
  • Electrical Testing
  • Software Testing
  • System Level Testing
CDR Agenda
(Topics to be covered)

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

• Section 6: User Guide Compliance
  • Summary
  • Power Interface
  • Telemetry Interface
CDR Agenda
(Topics to be covered)

• Section 7: Project Management Plan (PMP)
  • Team Organization Chart
  • Contact Matrix
  • Preliminary Schedule
  • Mentors / Supporters
  • Monetary Budget
  • Worries
  • Conclusions
Section 1
Mission Overview

Presenter: Andrew Rath
Mission Statement

• The mission of Project Hermes’s flight on RockSat-X 2017 is to demonstrate the functionality of the 1U Hermes Cube and to record video during flight using a VR camera.

• The STAR Experiment is designed to collect experimental data which will be used to validate new computational tribocharging (charge accumulation) models of grain interactions.

• The direct beneficiaries are the members of Team Hermes. Team Hermes will fly the Hermes 1U Cube on the CACTUS CubeSat mission slated for launch in December 2017.

• Flying on ROCKSAT-X 2017 will allow team Hermes to test the functionality of the 1U Hermes Cube and obtain a set of “lessons” learned.
Mission Objectives

• The primary mission objective on the ROCKSAT-X 2017 flight is to test the functionality of the Iridium 9603 SBD modem and other components that are slated to fly on the CACTUS mission.

• The secondary mission objective is to record video of the flight using a VR camera.

• The third mission objective is to fly components from the University of Maryland at College Park. These components are being tested for future space flights.
The underlying engineering concept behind Project Hermes is to test satellite to satellite communications for CubeSats. The idea here is to use existing communications networks such as the Iridium network.

Project Hermes flew a WIFI Iridium Modem and a smartphone in space on RockSat-X 2015 with success. Other institutions have flown Iridium modems in space. The main goal for team Hermes is to test the functionality of their equipment in space.

The 2017 flight will be different in that the team mostly wants to test the functionality of a different kind of Iridium modem and systems that will fly on a CubeSat in 2017.
Hermes Heritage

• Team Hermes flew on RockSat-X 2015 and were able to:
  • Establish Wi-Fi network in space for system bus use
  • Pair an Android Smartphone in space to an Iridium-based Wi-Fi hotspot device
  • Use & program applications (such as Iridium and various Android automation apps) available in the Google Play store to function as our Flight Software (FSW).
  • Use TCP / IP devices (smartphone & smartwatch (used by Aaron Bush)) on the ground as our Telemetry & Command System.

• Here are some links to videos from our YouTube channel:
  • [https://www.youtube.com/watch?v=zGcHYIxdTc4](https://www.youtube.com/watch?v=zGcHYIxdTc4)
    • (Shows the rocket launch as seen from the PI’s cell phone)
  • [https://www.youtube.com/watch?v=R7cdO9cPnCY](https://www.youtube.com/watch?v=R7cdO9cPnCY)
    • (Video recorded by Colorado University Boulder; you can see our wonderful planet Earth, as well as parts of the rocket falling back. You can also see the antenna used for the Project Hermes Payload)
  • [https://www.youtube.com/watch?v=G548GDgeWj4](https://www.youtube.com/watch?v=G548GDgeWj4)
    • (Video from the MOC (a tent on the launch pad and our victory cheer) In the victory cheer video, the team was calling out their mission sequence in the tent.)
• The Astronautical Engineering department and the Alumni Fusion Lab have served as incubators for the following programs:
  • High Altitude Balloon Launches
  • RockSat-X Launches
  • CACTUS-1 Mission

Wallops Island from 95 miles high, TRAPSat

TRAPSat’s RockSat-X Payload 2016
1. **Launch**
   - Hermes Cube/system will power on using a signal from rocket Launch to Apogee
   - Hermes Cube will switch to internal power
   - The VR camera/UMCP’s STAR experiment will power on

2. **Apogee**
   - Hermes Cube shall transmit housekeeping data using Iridium
   - VR Camera will continue to record

3. **Descent**
   - Hermes Cube shall transmit housekeeping data using Iridium
   - VR Camera will continue to record

4. **Chute Deploy**
   - Hermes Cube shall transmit housekeeping data using Iridium
   - VR Camera will continue to record

5. **Landing**
   - Hermes Cube shall transmit housekeeping data using Iridium
   - VR Camera will continue to record
<table>
<thead>
<tr>
<th>Event</th>
<th>Time On</th>
<th>Units</th>
<th>Dwell Time</th>
<th>Units</th>
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<tr>
<td>GSE 1</td>
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<td>(T-X) (sec)</td>
<td>N/A</td>
<td>(sec)</td>
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<td>N/A</td>
<td>(T-X) sec</td>
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<td>(sec)</td>
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<td>(T+X) (sec)</td>
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<td>(sec)</td>
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<td>TE-1</td>
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<td>(T+X) (sec)</td>
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<td>N/A</td>
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<td>N/A</td>
<td>(sec)</td>
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<td>N/A</td>
<td>(T+X) (sec)</td>
<td>N/A</td>
<td>(sec)</td>
<td>N/A</td>
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<tr>
<td>TE-R</td>
<td>0:01</td>
<td>(T+X) (sec)</td>
<td>1</td>
<td>(sec)</td>
<td>Our relay circuit will provide a signal to the USB rechargeable external battery packs contained in each of the various compartments. Each compartment will carry its own internal power supply. No devices will recharge using ROCKET power, the TE line is only used as an &quot;ON SIGNAL&quot; to our battery pack.</td>
</tr>
</tbody>
</table>

Team Name: PROJECT HERMES CAPITOL TECHNOLOGY UNIVERSITY
Date: 12/09/16
Expected Results

• If all works as designed, the team should expect telemetry data from the Iridium SBD modem and be able to command the payload from the ground. The VR camera should contain a video recording from launch to splashdown.

• The important goal here is to not quantify data but to simply obtain lessons learned. There is no real “set” pass or success benchmark for this mission. The team simply wants to fly the 1U Hermes Cube in space for functional testing.
  • The team wants to apply the lessons learned for the CubeSat mission.
Success Criteria

• The minimum success criteria is to receive a single telemetry point from the Iridium 9603 SBD modem. The team will also try to obtain location data from the Iridium messages to report the payload’s location.

• Comprehensive success criteria would include; receipt of data from the modem throughout flight duration, for the payload to survive the flight, and finally to capture and recover a VR recording of the flight. Be able to downlink STAR’s messages.
## Top Level Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>The on signal will be distributed to components throughout the payload.</td>
<td>Test</td>
<td>Payload components will all receive and continue to receive power from battery packs. Has been tested on the ground as well as on High Altitude Balloon flights. Will continue to test with more HAB launches to come.</td>
</tr>
<tr>
<td>Able to receive “Hello” and continued data from Hermes cube. Also, transmit UMPC’s status messages.</td>
<td>Test</td>
<td>Data and commands will flow through the Iridium Network to and from modem. Has been tested on the ground as well as on High Altitude Balloon flights. Will continue to test with more HAB launches to come.</td>
</tr>
<tr>
<td>Hermes cube components will fit inside 1U cube.</td>
<td>Inspection</td>
<td>This requirement can be verified by a visual inspection of CAD model or physical components and printed cube.</td>
</tr>
<tr>
<td>VR Camera captures and stores recording.</td>
<td>Demonstration</td>
<td>Requirement can be demonstrated and verified on the ground through normal off the shelf operation.</td>
</tr>
</tbody>
</table>

12/09/2016

Project Hermes RockSat-X 2017 (CDR)
Section 2
System Overview

Presenter: Samuel Lawson
Science Design Overview

• Hermes will not be flying any science as a part of its mission

• However, UMCP will be conducting science with its STAR experiment
STAR: Stratification and Tribocharging Analysis of Regolith

University of Maryland Space Systems Lab
In partnership with
Capitol Technology University
UMD RockSatX Team – Background Information

• STAR is being developed by the Balloon Payload Team in the Space Systems Lab of the Aerospace Engineering Department at UMD
  • Balloon Payload Program was started in Fall 2003 after Faculty Advisor (Mary Bowden) attended the Colorado Space Grant BalloonSat Workshop
  • Program funded by MD Space Grant Consortium and directed by UMD
  • High altitude ballooning program has flown 60 tracked flights in Mid-Atlantic area
  • Hundreds of student-built payloads have been tested and flown over the year
  • Numerous joint flights with Cap Tech Univ coordinating particularly on tracking and photography

• Experience with developing hardware for nearspace environments
  • Development of Balloonduino board for sensing, logging, and controlling payloads on HAB flights
  • Reliable redundant tracking module using APRS, cell tracker, and 900MHz radio systems
  • Team has also participated in 4 HASP Balloon Flights from Ft. Sumner, New Mexico (2008-2011)
UMD STAR Team

• Advisors
  • Dr. Mary Bowden, Faculty Advisor for UMD Team, 60+ balloon flights, 1 SSTS Flight Experiment
  • Steve Lentine, KD2DRI, Aerospace Engineer at Goddard Space Flight Center, 2 ISS missions, 1 CubeSat, 15 balloon flights
  • Nick Rossomando, KD2IFB, Aerospace and Software Engineer at FedCentric Technologies, 17 balloon flights

• Principal Investigator
  • Dr. Christine Hartzell, Assistant Professor of Aerospace Engineering at UMD, Head of Hartzell Lab

• Upperclassmen
  • Camden Miller, KC3EMV, Senior Aerospace Engineering, 14 balloon flights
  • Bianca Foltan, KD2JUC, Junior Aerospace Engineering, 13 balloon flights
  • Michael Walker, KC3HHV, Senior Aerospace and Nuclear Engineering, 9 balloon flights

• Underclassmen
  • Aravind Ramakrishnan, Sophomore, Computer Science and Physics, 11 balloon flights
  • Joseph Breeden, Sophomore, Aerospace Engineering, 6 balloon flights
  • Blaire Weinberg, Freshman, Aerospace Engineering and Astronomy, 4 balloon flights
  • Quinn Kupec, Freshman, Aerospace Engineering, 3 balloon flights
**Experiment Description: STAR**

- **Goals:**
  - Observe stratification of varying bimodal grain size distribution under microgravity and external excitation
  - Measure effect of tribocharging upon spherical non-conducting grains

- **Results** will contribute to the understanding of the physics of tribocharging and will aid in computational modeling of spacecraft-regolith interactions

- **Microgravity and vacuum conditions** are essential requirements for this experiment

- **Data to be collected:**
  - Video capture of grain-stratification process due to shaking in weightlessness
  - Timestamps of mission events (eg. activation of electric field)
  - 3-axis accelerometer and gyroscope readings
Science Data

Primary:
- Images of grain segregation caused by ambient and induced excitation
- Images of electromagnetic acceleration of grains under applied electric field

Secondary:
- Accelerations and Rotations of base during flight
- Hardware/software status

Grain distribution and accelerations extracted from videos via image analysis

Requires knowledge of base accelerations
Payload Overview

- Camera
- Sample Illumination
- Starduino
- Translational Shaker Stage
- Samples
Concept of Operations

- Mission timeline
  - L+0: Launch
  - L+0.01s: Power Up, start high gain accelerometer data collection, start image capture
  - L+5.2s: Terrier burnout
  - L+17.4s: Malamute ignition
  - L+29.1s: Malamute burnout
  - L+35s: Switch to low gain accel
  - L+70s: Skirt separation, Iridium acquisition, start telemetry sending
  - L+71s: Start grain excitation shaking
  - L+191s: Stop grain excitation, Apply bias current
  - L+210s: Apogee
  - L+325s: End current application
  - L+332s: Rocket-powered experiments Power Off
  - L+346s: Maximum Reentry Heating
  - L+460s: Chute Deploy
  - L+882s: Splash Down
Interface with HERMES (and Rocket)

- No direct interface with rocket, all interfaces are with CapTech payload
- ICD between STAR and HERMES in place
- Mechanical:
  - STAR mechanical footprint
- Power
  - Provided through HERMES payload (no separate interface to rocket)
    - Provide 5V, 2A
    - Current Draw: 490mA (avg), 710mA (peak)
    - Battery Capacity: 450mAh
- Data:
  - Telemetry relayed by HERMES Iridium connection (2.4kbit/s)
  - Telemetry sent to HERMES via RS232 connection via start/stop commands
  - Data formatted as CCSDS packets
    - Telemetry generation code has flight heritage
  - Link Budget:
    - Total: 46Bps
Mechanical Design

- 3 test tubes with differing distributions of glass-bead grains
- Shaker system to excite grains in microgravity
  - Linear bearings provide 1 DOF motion
- Camera records interactions of grains
  - Illumination provided by LEDs
- Electrodes at ends of test tubes to
- allow grain charge measurement
- Structure: Aluminum 6061
- Mass Budget:
  - Total: 0.366 kg (0.807 lb)
Mechanical Design
Mechanical Design
Electronics Overview

• STARduino
  • Arduino based with integrated environmental and engineering sensors
  • Derived from Balloonduino which has flight heritage from 5+ balloon flights
  • Specialized hardware:
    • Onboard data logging
    • Shaker Driver
    • Experiment bias boost driver
    • LED illumination

• Image Recording
  • Raspberry Pi Camera
  • Raspberry Pi Zero

• Power Routing
  • Cabling insulated with non-outgassing PTFE

• Other
  • All boards conformal coated for thermal/mechanical support
Software Design

- Written in C++
- Leverages Arduino environment and community and heritage balloon code
Mission Success

• Mission Success Criteria

• Minimum
  • Return 30Hz images of grains throughout all phases of flight

• Comprehensive
  • Return 30Hz images of grains throughout all phases of flight
  • Record accelerometer and gyroscope readings at 30Hz
  • Record status of software and hardware, including camera sync pulse, throughout flight
## Risks

<table>
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<tr>
<th>Risk</th>
<th>Likelihood</th>
<th>Impact</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illumination Failure (1,2-5)</td>
<td>Low (1)</td>
<td>Medium/Critical (2-5)</td>
<td>Will have multiple LEDs, failure of one may reduce quality of images, failure of all would prevent images from being captured</td>
</tr>
<tr>
<td>Camera Failure (1,5)</td>
<td>Low (1)</td>
<td>Critical (5)</td>
<td>No images recorded, no science</td>
</tr>
<tr>
<td>Shaker Failure (2,2)</td>
<td>Medium (2)</td>
<td>Medium (2)</td>
<td>Launch loads and attitude control maneuvers will still excite grains</td>
</tr>
<tr>
<td>Experiment Bias Voltage Failure (2,2)</td>
<td>Medium (2)</td>
<td>Medium (2)</td>
<td>Grain segregation data will still be collected, charge measurement not possible</td>
</tr>
<tr>
<td>Telemetry Failure (2,1)</td>
<td>Medium (2)</td>
<td>Low (1)</td>
<td>All data logged onboard, telemetry is non-mission critical</td>
</tr>
</tbody>
</table>
Path to I&T

• Payload testing:
  • Engineering model of payload complete (January 2017)
  • Day in the life (UMD, stand alone)
  • Iridium telemetry test (CTU, integrated)
  • Splashdown Test (UMD, integrated)
  • Vacuum testing (UMD, integrated)
  • Thermal testing (UMD, integrated)
  • Balloon flight (UMD, April 2017, integrated)
  • Vibration testing (UMD, integrated)
  • Day in the life (UMD, integrated)
  • Interface Testing (WFF, June 2017)
  • Integration Testing (WFF, August 2017)
UMD Facilities

- Development Lab
  - Balloon program payload development lab

- Thermal Chamber
  - Range: -65C to 200C

- Vibration Table
  - 1 axis
  - Maximum: 20G’s

- Vacuum Chamber
  - Minimum pressure: 0.1 PSI

- Neutral Buoyancy Facility
  - 50ft diameter, 25ft deep tank
  - Used for splashdown testing
The Hermes payload will be designed to closely mimic the 1U CubeSat configuration. It will be divided into (3) sections:

- **1U Hermes Cube**
  - Contains Flight Computer, Iridium Modem, Antenna, batteries, and solar panels

- **VR Camera Block/ Power Block**
  - The power block will take the power from the rocket and provide an “on” signal to equipment in all (3) sections of the overall Hermes Payload

- **UMPC’s STAR Experiment**

Hermes has no major technology dependencies at this time.
Changes Since the PDR

• There have been no major changes to the Hermes design or mission since the PDR.

• However, we will now be flying an additional experiment from UMCD.
  • None of this will impact our mission objectives or requirements.

• UMCP payload will seamlessly integrate with Project Hermes.
  • Hermes will provide power and telemetry to UMCP's STAR experiment.

• CTU's path to integration will be in sync with UMCP's.
Functional Block Diagram

1U Hermes Cube

Iridium 9603 Modem

FSW Computer

Antenna

Battery 2

VR Camera

Battery 2/ Power Circuit

VR Camera

Battery 1

Relay

Silicon Controlled Rectifiers

Voltage Regulator

Power Circuit/Added Experiment Cube

UMCD STAR

Wallops Rocket Power

TE-R (T+0.01 sec)
The Hermes case will be divided into (3) sections for the various subsystems.

Currently using a 3D printed frame, but final frame will be aluminum.

No extensive stress/strain analysis has been conducted at this time. Preliminary studies underway.
The diagram depicts a 2D TOP DOWN representation of the various compartments within the structure.

- The Hermes CUBE should resemble a 1U CUBESAT
- Power circuits and Added Experiments all be contained in a 1U cube format
- Added space is given to the VR Camera
- The lens opening shall provide a view of the earth

The pointing requirements are as follows:

- The Iridium antenna must point zenith (towards space)
- The VR camera must point towards Earth

The overall structure has the following dimensions:

- Length = 7 inches
- Width = 8 inches
- Height = 5 inches
- Antenna = 1.89”
- Lens Opening = 1.89”
Mechanical Design
Bottom View
Electrical Design Overview

- Initial 28V from rocket will be stepped down to 5V and used to start batteries and other systems
- (2) Pins to the Pi allow for data input from the sensors
- (3) Leads to Sensors:
  - 0) Small Thermostat: Triggers heater when temperature drops too low
  - 1) Voltmeter: Measures battery charge
  - 2) Spare Lead
Power Circuit

Rocket Power, 28 VDC

5V Regulator

R10

1k

C10 5pF

C9 5pF

GND

OPTO

Battery Pack

5V Out

5V to Pi, Iridium Board, VR Camera, UMCP STAR
Logic Circuit

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<tr>
<th>Pin 16</th>
<th>Pin 18</th>
<th>Channel</th>
<th>Address</th>
<th>Purpose</th>
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<td>5V</td>
<td>0V</td>
<td>0</td>
<td>1000</td>
<td>Temperature</td>
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<td>0V</td>
<td>5V</td>
<td>1</td>
<td>0100</td>
<td>Voltage</td>
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<td>5V</td>
<td>5V</td>
<td>2</td>
<td>0010</td>
<td>Spare</td>
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<tr>
<td>0V</td>
<td>0V</td>
<td>3</td>
<td>0001</td>
<td>OFF</td>
</tr>
</tbody>
</table>
Software Design Overview

• Upon software boot the system will power up the Iridium modem and begin a process of recording and timestamping IRU data

• IRU data and UMCP’s STAR data will then be downlinked via the Iridium modem

• The system will continue running for the duration of the flight until battery power dies
Software Flow Diagram

FSW Build 1:
Command used:
SBDREG
MISSMT
SBDX
SBDWST
CGMI

FSW Boot
Power on Modem
Register Modem
Read Cmd response
Status: Pass
Send event message
Read Inst. Data (Send to Modem)
Start SBD session
Status: Pass
Get latest network time
Process cmd
Return
Check for new cmd
Partnerships

- We are partnering with the University of Maryland at College Park
- The partnership has involved coordination on two joint balloon test flights
- UMCP's experiment will fly as part of our payload
- It will comply with Hermes' power requirements and will merely be a plug and play experiment
De-Scopes and Off-Ramps

- No de-scopes
- Project dependant on budget approval.
- If system fails failure of experiment.
- This mimics a satellite flight environment
Special Requests

• Need to know the orientation of the rocket after stabilizing for proper antenna and camera placement.
  • Iridium Antenna needs to be Zenith Pointed
  • VR Camera needs to be Nadir Pointed
Subsystems

- Independent Power System
- Hermes CTU Science Payload
- VR camera Experimental Payload
- University of Maryland College Park (UMCP) STAR
Power Systems

• Electrical hardware and its weight
  • Battery pack (w/o batteries): 415.5g
  • Batteries (18650): 43.525g
  • Subtotal weight: 459.025g
Power System Battery Pack
Hermes System

- Hermes Hardware and individual weights
  - Modem: 30.904g
  - Antenna: 13.509g
  - Raspberry Pi Zero: 11.289g
  - Subtotal weight: 55.702g (current)
  - Hermes cube in total: 303.4g
VR Camera

• VR Camera has independent internal power supply, only requires initial data pulse to activate.
• VR Camera Battery is 2610 mAh Lithium-Ion Battery
• VR Camera Weight is 230 g.
VR Camera
Risk Matrix – Main BUS

### Main BUS Risk Matrix

<table>
<thead>
<tr>
<th>Risk No.</th>
<th>Risk Description</th>
<th>Likelihood</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>MB.R1</td>
<td>Reusable hardware will be destroyed by reentry heating</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>MB.R2</td>
<td>Reusable hardware will be destroyed if salt water penetrates hardware</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>MB.R3</td>
<td>BUS may shut down due to excessive heating due to radiation</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>MB.R4</td>
<td>BUS may shut down due to excess vibrations</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>MB.R5</td>
<td>Power may be lost in the batteries for the BUS if it sits alone for several days</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

#### Likelihood and Consequence

<table>
<thead>
<tr>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

**Likelihood:** 1 - Not possible, 2 - Rare, 3 - Unlikely, 4 - Likely, 5 - Certain

**Consequence:** 1 - Negligible, 2 - Minor, 3 - Moderate, 4 - Significant, 5 - Severe
## Comms Risk Matrix

<table>
<thead>
<tr>
<th>Risk No.</th>
<th>Risk Description</th>
<th>Likelihood</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.R1</td>
<td>Iridium antenna may incur signal loss if it does not have access to sky</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>C.R2</td>
<td>Modem does not boot</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>C.R3</td>
<td>FSW board does not boot</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>C.R4</td>
<td>Battery does not provide power</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>
### Risk Matrix

#### Power Risk Matrix

<table>
<thead>
<tr>
<th>Risk No.</th>
<th>Risk Description</th>
<th>Likelihood</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPS.R1</td>
<td>The electrical system could fail if the circuit cannot dissipate heat</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>EPS.R2</td>
<td>The electrical system would fail if the circuit ruptures due to G-forces</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>
## Detailed Weight Budget

- Hermes components weight: 55.702g
- VR Camera Weight: 230 g
- Power Bus Weight: 459.025g
- STAR weight: 360 g
- Total of component weight of experiments: less than 7 kg
- Total weight of experiments + structure + ballast = 7 kg +- 0.5
## Detailed Power Budget

Capitol Technology University - Power Budget (for Relay Circuit, to route power from rocket to internal)

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Voltage (V)</th>
<th>Max Current (A)</th>
<th>Start Time (sec)</th>
<th>Time On (sec)</th>
<th>Watts</th>
<th>Ah</th>
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<tr>
<td>Power Relay Circuit</td>
<td>28.0</td>
<td>1.50</td>
<td>0.1</td>
<td>2</td>
<td>42.00</td>
<td>0.00</td>
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<td></td>
<td></td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

| Total                    | 1.50        |                 |                  |               | 42.00 | 0.00 |

| Total Power Capacity     |             |                 |                  |               |       | 1.00 |
| Over/Under               |             |                 |                  |               |       | 1.00 |

# of Flights Margin       | 1200.0      |
Finalization

- At this time the Hermes science payload and experimental payload is finalized. The design has been verified to be flight worthy and structural design adequate for functionality of the experiments. This has been tested and verified through 3 separate successful balloon flights, we are awaiting to complete the integration of the UMCP STAR experiment to finalize our subsystem design to 100%
Section 4
Prototyping/Analysis And Testing Plan

Presenter: Ian Hastings and Patrick Molloy
Prototyping Results / Plans

• The Hermes Cube and VR Camera have been Tested on High Altitude Balloons
  • These balloons expose the systems to near space environments (Low Pressure, Low Temperature, unstable system)
  • Both systems worked at an altitude of 75,000 feet
  • Iridium modem was able to communicate on an extremely unstable string
  • VR camera worked until it reached –20°C
• **Structural Analysis using CAD**
  
  • Stress tests showed us weak points in our design, but nothing that affects the performance of the Satellite
Mechanical Testing

- Structure must be able to reliably hold all components, and all physical components must survive the launch and space environment.
- Vibration testing and thermal vacuum testing will be done during spring, March/April with the University of Maryland.
- Hermes Cube and VR Camera have been tested in a near space environment.
Electrical Testing

• The power circuit must provide reliably regulated voltage and all electric components must be able to work in the rocket environment.

• This will be tested on the ground by simulating the power the rocket provides and monitoring the output.
Software Testing

- Software will be tested on the ground by running the code and monitoring the messages received from the Iridium modem.
- Software only requires that the Hermes Cube be put together electronically to be tested.
- Initial revisions of software have been tested on the high altitude balloon and have proven reliable and successful.
System Level Testing

- The system as a whole will be tested on a high altitude balloon in April in conjunction with the university of Maryland.
- The system will also undergo vibration testing as well as a thermal vacuum test at the University of Maryland.
Prototype Photos
Low Altitude Balloon Launch
Section 5
Manufacturing Plan

Presenter: Ethan Ames
Mechanical Elements

• Structure (aluminum 6061 tubes) parts to be ordered and will be fabricated in January through February of 2017.

• Aluminum for the structure will need to be purchased as well as a new modem to replace the one lost in a recent test.
Electrical Elements

- The first prototype for the circuits has been completed
- The prototype will be revised as needed
- The Modem needs to be purchased again due to its loss
Software Elements

• The software is all completed, only revisions of existing code remain.

• The software depends on the modem functioning in order for data to be collected and sent.
Section 6
User Guide Compliance

Presenter: Sophia LoSchiavo
<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>Will maintain within 1”</td>
</tr>
<tr>
<td>Weight 30.0+/- 1.0 (15.0 +/- 0.5) lbs.?</td>
<td>(15.0 +/- 0.5) lbs.</td>
</tr>
<tr>
<td>Max Height &lt; 10.75” (5.13”)</td>
<td>5”</td>
</tr>
<tr>
<td>Bottom of deck has flush mount hardware?</td>
<td>Yes, Shared Mount</td>
</tr>
<tr>
<td>Within Keep-Out Zone</td>
<td>Will maintain all borders</td>
</tr>
<tr>
<td>Using &lt; 10 A/D Lines</td>
<td>N/A</td>
</tr>
<tr>
<td>Using/Understand Parallel Line</td>
<td>N/A</td>
</tr>
<tr>
<td>Using/Understand Asynchronous Line</td>
<td>N/A</td>
</tr>
<tr>
<td>Using X GSE Line(s)</td>
<td>No</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>Yes</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, 1616-1626.5 MHz, 7.5W Max Transmit</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>Yes</td>
</tr>
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</table>
## Power Interface

<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>N/A (will not be used by CTU)</td>
</tr>
<tr>
<td>2</td>
<td>Timer Event Redundant (TE-RA)</td>
<td>(T+0.1 sec), Initialization Circuit. Pins 2&amp;3 tied together</td>
</tr>
<tr>
<td>3</td>
<td>Timer Event Redundant (TE-RB)</td>
<td>(T+0.1 sec), Initialization Circuit. Pins 2&amp;3 tied together</td>
</tr>
<tr>
<td>4</td>
<td>Timer Event 1 (TE-1)</td>
<td>N/A (will not be used by CTU)</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td>Tied to common Ground</td>
</tr>
<tr>
<td>6</td>
<td>GND</td>
<td>Tied to common Ground</td>
</tr>
<tr>
<td>7</td>
<td>GND</td>
<td>Tied to common Ground</td>
</tr>
<tr>
<td>8</td>
<td>GND</td>
<td>Tied to common Ground</td>
</tr>
<tr>
<td>9</td>
<td>GSE 2</td>
<td>N/A (will not be used by CTU)</td>
</tr>
<tr>
<td>10</td>
<td>Timer Event 2 (TE-2)</td>
<td>N/A (will not be used by CTU)</td>
</tr>
<tr>
<td>11</td>
<td>Timer Event 3 (TE-3)</td>
<td>N/A (will not be used by CTU)</td>
</tr>
<tr>
<td>12</td>
<td>GND</td>
<td>N/A (will not be used by CTU)</td>
</tr>
<tr>
<td>13</td>
<td>GND</td>
<td>N/A (will not be used by CTU)</td>
</tr>
<tr>
<td>14</td>
<td>GND</td>
<td>N/A (will not be used by CTU)</td>
</tr>
<tr>
<td>15</td>
<td>GND</td>
<td>N/A (will not be used by CTU)</td>
</tr>
</tbody>
</table>
Section 7
Project Management Plan (PMP)

Presenter: Sarah Sharpe
Team

- Andrew Rath
- Sophia LoSchiavo
- Ian Hastings
- Erik Schroen
- Sarah Sharpe
- Ethan Ames
- Samuel Lawson
- Russell English
- Patrick Molloy
- Roy Brown
- Dean Zinetti

- Steve Lentine
- Aravind Ramakrishnan
- Blaire Weinberg
- Quinn Kupec

12/09/2016
Team Schedule

- Team Hermes meets every Monday at 6:30 pm ET.
- RockSat-X members meet every Thursday at 4:00 pm ET.
- The Hermes team is committed to meeting all project deadlines.
- The schedule for meetings and builds will change as needed to accommodate the team schedule conflicts.
Mentors

- **Professor Rishabh Maharaja** 2015 PI and 2017 CO/PI – Hermes Advisor/Concept Developer, RockSat-X 2015 PI
- **Dr. Hartzell** – UMCP STAR Experiment PI
- **Marcel Mabson** – FSW/OpsCon/Systems Engineering Support
- **Former members from Hermes RockSat-X 2015**
- **Daniel Bottner** – Structural Fabrication
- Iridium modem support from **JouBeh Technologies**
- Iridium Antenna support from **Maxtena Inc.**

12/09/2016 Project Hermes RockSat-X 2017 (CDR)
# Contact Matrix

## CACTUS Technology Demonstrator (CTD) / Capitol Technology University

<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>Super Boss (PI)</td>
<td>Angela Walters</td>
<td>1-240-554-7278</td>
<td>1-240-554-7278</td>
<td>Yes</td>
<td><a href="mailto:awalters@captechu.edu">awalters@captechu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Co-PI</td>
<td>Rishabh Maharaja</td>
<td>1-410-967-8703</td>
<td>1-410-967-8703</td>
<td>Yes</td>
<td><a href="mailto:rymaharaja@captechu.edu">rymaharaja@captechu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Hermes RockSat Project Lead</td>
<td>Sophia LoSchlavo</td>
<td>1-570-351-4878</td>
<td>1-570-351-4878</td>
<td>Yes</td>
<td><a href="mailto:seloschlavo@captechu.edu">seloschlavo@captechu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Hermes RockSat Project Lead</td>
<td>Andrew Rath</td>
<td>1-858-382-6156</td>
<td>1-858-382-6156</td>
<td>Yes</td>
<td><a href="mailto:andrew.t.rath@gmail.com">andrew.t.rath@gmail.com</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Hermes FSW Lead</td>
<td>Ian Hastings</td>
<td>1-443-497-8242</td>
<td>1-443-497-8242</td>
<td>Yes</td>
<td><a href="mailto:icantfly31297@gmail.com">icantfly31297@gmail.com</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Hermes Electrical Systems Lead</td>
<td>Erik Schroen</td>
<td>1-571-699-7806</td>
<td>1-571-699-7806</td>
<td>Yes</td>
<td><a href="mailto:eschroen2@gmail.com">eschroen2@gmail.com</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Sarah Sharpe</td>
<td>1-571-699-7806</td>
<td>1-571-699-7806</td>
<td>Yes</td>
<td><a href="mailto:ssharpe1997@gmail.com">ssharpe1997@gmail.com</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Samuel Lawson</td>
<td>1-410-422-5827</td>
<td>1-410-422-5827</td>
<td>Yes</td>
<td><a href="mailto:samlawson71@gmail.com">samlawson71@gmail.com</a></td>
<td>U.S.</td>
<td>Yes</td>
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<tr>
<td></td>
<td>Russell English</td>
<td>1-443-463-0116</td>
<td>1-443-463-0116</td>
<td>Yes</td>
<td><a href="mailto:engrus10@gmail.com">engrus10@gmail.com</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Dean Zinetti</td>
<td>1-856-745-7294</td>
<td>1-856-745-7294</td>
<td>Yes</td>
<td><a href="mailto:d.zinetti@gmail.com">d.zinetti@gmail.com</a></td>
<td>U.S.</td>
<td>Yes</td>
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<tr>
<td></td>
<td>Roy Brown</td>
<td>1-818-631-6041</td>
<td>1-818-631-6041</td>
<td>Yes</td>
<td><a href="mailto:durka715@gmail.com">durka715@gmail.com</a></td>
<td>U.S.</td>
<td>Yes</td>
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</tbody>
</table>
# Monetary Budget

- The budget at this time remains TBD. The Maryland Space Grant Consortium (MSGC) will be approached for funding. MSGC funded the Project Hermes flight on RockSat-X 2015.
- We will not be able to report budget information until January.
## Monetary Budget Continued

### Budget for Travel to Wallops Island Virginia With Hotel

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<th>Description</th>
<th>Hotel Fee/Day</th>
<th>Breakfast/Day</th>
<th>Lunch/Day</th>
<th>Dinner/Day</th>
<th>Snacks/Day</th>
<th>Total</th>
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<tbody>
<tr>
<td>Faculty (1)</td>
<td>$ 70.00</td>
<td>$ 13.00</td>
<td>$ 13.00</td>
<td>$ 13.00</td>
<td>$ 5.00</td>
<td>$ 114.00</td>
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<tr>
<td>Faculty (2)</td>
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<td>$ 13.00</td>
<td>$ 13.00</td>
<td>$ 13.00</td>
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<tr>
<td>Student 1</td>
<td>$ 70.00</td>
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<td>$ 13.00</td>
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<td>$ 114.00</td>
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<tr>
<td>Student 6 Meal Covered By</td>
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<td>$ -</td>
<td>$ -</td>
<td>$ 13.00</td>
<td>$ 5.00</td>
<td>$ 88.00</td>
</tr>
<tr>
<td>Rocksat</td>
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<td></td>
<td></td>
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<tr>
<td>Student 7 Meal Covered By</td>
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<td>$ -</td>
<td>$ -</td>
<td>$ 13.00</td>
<td>$ 5.00</td>
<td>$ 88.00</td>
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<td>Student 8 Meal Covered By</td>
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<td>Rocksat</td>
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<tr>
<td>(2x) Minivan Rental/Day</td>
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<td>$ 140.00</td>
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<td>Total Cost/Day</td>
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<td>$ 6,850.00</td>
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<tr>
<td>Total Cost for 2 Weeks</td>
<td>$ 13,700.00</td>
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</tbody>
</table>

12/09/2016

Project Hermes RockSat-X 2017 (CDR)
Worries

• If our camera and antenna are not positioned the way we are requesting, we will not get the data we are looking for.

• If the Iridium antenna does not point towards space (zenith), all communications to the CubeSat will be lost.
Conclusions

• Team Hermes would like to use the RockSat-X platform to test the Hermes 1U CubeSat. The Hermes 1U CubeSat is slated to launch in December 2017. The RockSat program will allow us to test our model and obtain lessons learned.

• The flight on RockSat-X 2017 is the testbed. Any lessons learned will be our success criteria.

• Looking forward toward the STR, the team's next step will be to complete our precise design layout.
  • Waiting for equipment delivery
  • Continue creating a 3D printed model of the layout
  • Prepare for a launch on a high altitude balloon
Questions
APPENDIX
## Key Payload Requirements

<table>
<thead>
<tr>
<th>Requirement ID</th>
<th>Requirement Text</th>
<th>Verification Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAR-1</td>
<td>Shall comply STAR/HERMES ICD</td>
<td>Test</td>
</tr>
<tr>
<td>STAR-2</td>
<td>Shall be capable of enduring 32G loading along the thrust axis and 10G transverse axes with electronics active</td>
<td>Test</td>
</tr>
<tr>
<td>STAR-3</td>
<td>Shall collect optical images at 30Hz with resolution sufficient to identify individual grains (0.1mm -&gt; 1920x1080)</td>
<td>Test</td>
</tr>
<tr>
<td>STAR-4</td>
<td>Shall apply 28V to electrodes after shaking</td>
<td>Test</td>
</tr>
<tr>
<td>STAR-5</td>
<td>Shall store at least 30Hz 3 axis accelerometer and gyro measurements</td>
<td>Test</td>
</tr>
<tr>
<td>STAR-6</td>
<td>Shall support a high gain and low gain accelerometer mode</td>
<td>Test</td>
</tr>
<tr>
<td>STAR-7</td>
<td>Shall illuminate the FOV of the camera</td>
<td>Test</td>
</tr>
<tr>
<td>STAR-8</td>
<td>Shall telemeter software status and accel and gyro measurements at at least 1Hz when Iridium is available</td>
<td>Test</td>
</tr>
</tbody>
</table>
Sample Preparation

- Samples will contain various grain distributions
- Samples are sensitive to humidity
- Bakeout:
  - Samples will be baked out at UMD prior to launch
    - Will prepare flight and flight spare samples
  - Will be sealed with foil to prevent water incursion
    - Foil will burst when ambient pressure drops during launch and vent sample
- Samples will be swappable to support testing
Experiment Feasibility

• Concerns over the resolution of images and acceleration of grains during current application

• Pixel resolution at 1080p and assuming a 4”x2” field of view:
  • X resolution = .053mm/pixel
  • Y resolution = .047mm/pixel
  • Sufficient to resolve smallest grains

• Accelerations of particles calculated assuming 10-6 Coulombs of charging
  • Assumption made using previous data and experience by Dr. Hartzell
  • Also assume 28V bias voltage applied
  • Results in 4.72x10-4 m/s2 acceleration
  • Sufficient to accelerate particles with 2 minutes duration current application to electrodes
## Power Budget

<table>
<thead>
<tr>
<th>Component</th>
<th>Avg Current Draw (mA)</th>
<th>Peak Current Draw (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STARduino</td>
<td>140</td>
<td>200</td>
</tr>
<tr>
<td>Raspberry Pi Zero</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>PiCamera</td>
<td>150</td>
<td>200</td>
</tr>
<tr>
<td>LEDs</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Shaker Motor</td>
<td>90</td>
<td>150</td>
</tr>
<tr>
<td>Electrodes</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>490</strong></td>
<td><strong>710</strong></td>
</tr>
</tbody>
</table>
Power Consumption

• Estimated total power consumption: 450mAh

• Estimate assumes longest operating time is 30 minute ground test
  • All parts of payload except shaker motor operational for duration
  • Shaker motor operational for 10 test runs over duration
    • Five runs @ 2 minutes duration
    • Five runs @ 1 minute duration
  • Electrodes are powered 10 times over duration
    • Five applications @ 2 minutes duration
    • Five applications @ 1 minute duration

• Total is conservative
  • Includes 100% margin
## Mass Budget

<table>
<thead>
<tr>
<th>Part</th>
<th>Mass [g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raspberry Pi Zero</td>
<td>9</td>
</tr>
<tr>
<td>Test Tubes</td>
<td>10</td>
</tr>
<tr>
<td>Structure</td>
<td>200</td>
</tr>
<tr>
<td>Grains</td>
<td>5</td>
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<tr>
<td>PiCamera</td>
<td>4</td>
</tr>
<tr>
<td>Shaker</td>
<td>2</td>
</tr>
<tr>
<td>Fasteners/Wiring</td>
<td>100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>330</strong></td>
</tr>
</tbody>
</table>
Link Budget

• Data: 34 Bytes/sec
  • Software status flags
    • 2 x uint8 = 2 bytes * 1Hz = 2 Bps
  • Program time
    • 1 x uint32 = 4 Bytes * 1Hz = 4 Bps
  • Downsampling accelerometer measurements
    • 3 x Float = 12 Bytes * 1Hz = 12 Bps
  • Downsampling gyro measurements
    • 3 x Float = 12 Bytes * 1Hz = 12 Bps
  • Current measurement
    • 1 x Float = 4 Bytes * 1Hz = 4 Bps

• Total: 46 Bytes/sec
  • CCSDS header
    • 12 bytes * 1Hz = 12 Bps
  • Data
    • 34 Bps
**Logging Data Budget**

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Image Acquisition</strong></td>
<td>1920x1080 video @ 30Hz: 1.91 MB/s * 30min = 3.45GB</td>
</tr>
<tr>
<td></td>
<td>SD card at least 8GB</td>
</tr>
<tr>
<td><strong>Data</strong></td>
<td>Telemetry log: 64B/s * 30min = 115kB</td>
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<tr>
<td></td>
<td>Accel/Gyro/Mag = 12 bytes * 30Hz = 360 B/s * 30min = 648 kB</td>
</tr>
<tr>
<td></td>
<td>Event Timestamps = 4 bytes * 1Hz = 4 B/s * 30min = 7.2 kB</td>
</tr>
<tr>
<td></td>
<td>Status Flags = 2 bytes * 1Hz = 2 B/s * 30min = 3.6 kB</td>
</tr>
<tr>
<td></td>
<td>SD card at least 4GB</td>
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</tbody>
</table>
Component Selection

- Camera:
  - Raspberry Pi Camera Board v2

- Image Acquisition System
  - Raspberry Pi Zero

- Shaker
  - Linear Vibration Motor LV61228B
  - Vibration Motor 300-103

- Grains
  - 0.1mm grains
  - 0.5mm grains
  - Both from nextadvance.com
  - 1 lb packages

- Test tubes
  - GreatGlas test tubes
    - 0.5in diameter
    - 0.1in thickness
<table>
<thead>
<tr>
<th>Part</th>
<th>Cost</th>
<th>Quantity</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>PiCamera</td>
<td>$30</td>
<td>2</td>
<td>$60</td>
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<tr>
<td>Raspberry Pi Zero</td>
<td>$5</td>
<td>2</td>
<td>$10</td>
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<tr>
<td>2” x 24” x 0.15” AL6061</td>
<td>$20</td>
<td>1</td>
<td>$20</td>
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<tr>
<td>0.5” AL6061 Rod Stock</td>
<td>$5</td>
<td>1</td>
<td>$5</td>
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<tr>
<td>Yoga Mat</td>
<td>$4</td>
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<tr>
<td>Test Tubes</td>
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<tr>
<td>0.1mm Grains (1lb)</td>
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<tr>
<td>0.5mm Grains (1lb)</td>
<td>$36</td>
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<tr>
<td>Linear Shaker</td>
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<tr>
<td>Conformal Coating</td>
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<tr>
<td><strong>Total</strong></td>
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<td></td>
<td><strong>$276</strong></td>
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</tbody>
</table>
Recent BPP Projects

- Developed in-flight command and telemetry system
  - 900MHz radios and Xbee
- AeroSS
  - Active control of aerofoils for azimuthal attitude control
- MARS
  - On-command mechanical cutdown system
- Helios
  - Balloon altitude control and helium vent system
- Balloon Attitude Determination and Stabilization System
  - Attitude control with reaction wheels for hosted payload
- In house tracking software
  - APRS parser and radio interface