Arizona Space Grant Consortium
Conceptual Design Review

Organization:
Arizona Space Grant Consortium &
Arizona Space Flight and Research Collaboration

Team Members:
Andrew Okonya, Andràs Szép, Cathy McIntosh, Duffy Elmer, James Cook, Joel Thibault, Màrton Szép, Sean Hopta, Shobitha Jillella, & Steve Smith

October 9, 2017
Mission Overview: Mission Statement

• The goal of the payload is to:
  – expand digital camera stabilization technology
  – measure ionizing radiation
  – observe radiation effects on bacteria and immune cells
  – measure atmospheric data using a low-cost LiDAR system
Video Processing Mission Overview: Mission Objectives

• Mission Objectives:
  – utilize the rocket’s helix like motion and a large angle camera to generate a cylindrical image of the flight
  – create an virtually explorable visualization of the flight

• System requirements:
  – Must have structural strength to survive the flight conditions to space and back
  – Must be compatible with port specification
  – Must have the ability to record full flight duration with at least 40 FPS

• Minimum success criteria for data:
  – Still images are taken throughout the flight and saved
Video Processing Mission Overview: Theory & Concepts

– Team has previously developed digital stabilization/processing technology for large angle cameras over past 2 years
– Successfully tested this technology on two high-altitude (>100,000 feet) balloon flights as part of the ASCEND project
– Stabilization technology worked remarkably well in both cases:

Video showcasing the first iteration of our digital stabilization technology.
Video Processing Mission Overview: Theory & Concepts

• Created Virtual Reality (VR) ready 4k footage of high-altitude flights (see video below - please use Chrome when viewing footage)
Video Processing Mission Overview: Theory & Concepts

–Technologies our stabilization employs:
  • Masking
  • Feature identification
  • Feature matching
  • Rotational correction

–Enhanced stabilization technology for NASA’s Nationwide Eclipse Ballooning Project
Life Sciences Mission Overview: Mission Objectives

• Mission Objectives:
  – Investigate the short-term mutagenic effects of ionizing radiation on the bacterium *Salmonella enterica* subsp. *enterica* serovar typhimurium via the Ames *Salmonella* mutagenicity assay
  – Study short-term effects of ionizing radiation in human CD4+ T cells

• System requirements:
  – Must have successful transportation of biological samples to space and back
    • Accommodate extreme acceleration, rotation
  – Must avoid use of any mechanical input to keep specimens viable
    • Provide nutrients, air, temperature; prevent contamination

• Minimum success criteria for data:
  – Prepare, launch, and recover microorganisms of a scientifically relevant nature, while keeping them alive
Life Sciences Mission Overview: Theory & Concepts

• Ames Mutagenicity Assay
  – Tests whether a test stimulus is a mutagen
  – Uses strains of *Salmonella typhimurium* bacteria which carry mutations in genes which code for the synthesis of histidine
  – The *Salmonella* culture is transferred to a plate containing a medium with minimal histidine, along with the test stimulus
    • A control plate is also prepared in the same manner, without the test stimulus present
  – After incubation at 37 degrees Celsius, the two plates are observed for colony growth
    • If colony growth on the test plate is greater in relation to the control plate, the test stimulus is said to be a mutagen
Why study *Salmonella*?
- Pathogenic *Salmonella enterica* has been shown to upregulate its virulence factors in microgravity
- The effects of ionizing radiation in *Salmonella* have not been adequately investigated thus far

Why use Ames strains of *Salmonella*?
- The Ames strains are particularly sensitive to point mutations
- The Ames assay is a low-cost, efficient test to begin preliminary investigations into short-term effects of ionizing radiation on these bacteria
Life Sciences Mission Overview: Theory & Concepts

- **CD4+ T lymphocytes**
  - Also called helper T cells
  - They assist in the coordination of the immune response by recruiting other immune cells, such as macrophages, B cells, and cytotoxic T cells, to sites of infection
Life Sciences Mission Overview: Theory & Concepts

• Why use CD4+ T cells?
  – Research has documented lower CD4+ T cell count and lower general immune system function in astronauts who undergo long-term spaceflight
  – Exposure to high levels of ionizing radiation has been linked to lower proliferative capacity and cytokine production after the stimulation of T cell receptors
  – The specific effects of short-term ionizing radiation on human immune cells must be investigated further as more manned space missions are planned and executed
Life Sciences Mission Overview: Expected Results

- Since the *Salmonella* and CD4+ T cells will be in contact with elevated levels of ionizing radiation for a short amount of time, we expect a **minimal mutagenic effect of ionizing radiation** upon both of these organisms
  - **If both cultures are viable post-flight:** *Salmonella* and CD4+ T cells will each undergo DNA sequencing for frameshift and point mutation detections
  - **In post-flight analysis:** CD4+ T cells’ ability to express key surface receptors will be investigated further
LiDAR Mission Overview: Mission Objectives

- **Mission Objective:**
  - Collect data on *anthropogenic greenhouse gases* or an aerosol known to be abundant in near space using a low cost, lightweight LiDAR system

- **System requirements:**
  - Must be able to communicate with electronics system for data storage
  - Collection components must be able to fit within space requirements of access port
  - Laser must not require licensed operation
  - Laser must be able to interact with atmosphere
  - Must operate on 5-10mA of current with a 5V power supply

- **Minimum success criteria for data:**
  - Sensor will need to collect quantitative data through apogee for at least one aerosol
  - Must have a precision of at least less than 10%
LiDAR Mission Overview: Theory & Concepts

• Atmospheric lidar remote sensing
  – Functions by either
    • measuring backscatter from the atmosphere
    • measuring the scattered reflection off the ground (when the lidar is airborne) or other hard surface
LiDAR Mission Overview: Theory & Concepts

• Why Methane, Carbon Dioxide, Water?
  – Common anthropogenic aerosols
  – Best wavelengths for collecting data on each is well known
  – Relevance to interplanetary exploration
LiDAR Mission Overview: Theory & Concepts

• **LiDARS**
  – Widespread interest in CubeSat, UAV specific LiDAR advancement is growing
  – The technology gap between light and heavy LiDAR systems
  – We are interested in techniques that can facilitate **lightweight LiDAR improvements**
    • Synthetic array LiDARs
      – allows imaging LiDAR without the need for an array detector
    • **Wavelength Modulation Spectroscopy**
      – to enhance sensitivity and time response
LiDAR Mission Overview: Expected Results

• Expected decaying abundance of aerosol as rocket ascends
• Sensor equipment weight of 0.5 - 1 kg excluding power source
Radiation Mission Overview: Mission Objectives

• Mission Objective:
  – Use a Geiger counter to measure and record alpha, beta and gamma radiation for use in life sciences project

• System requirements:
  – Geiger counter must survive the flight through apogee and descent
  – Geiger must be powered during the entire flight

• Minimum success criteria for data:
  – Geiger counter must collect ionizing radiation data
Radiation Mission Overview: Theory & Concepts

Team will either be purchasing a new Geiger counter or repurposing an already experimentally
  • Previous component was used from RockOn! 2017

Our Geiger counter and data collection device will be flown on a high altitude balloon by Arizona State University’s ASCEND project in November to ensure proper function.
Radiation Mission Overview: Precautions

- Geiger counter will be coated with Conformal Coating to ensure no arcing among circuitry components
- Voltage and current draw of specific counter will be reported to Chris and Audrey to satisfy variance request
Design Overview

Name of Presenter(s)
Joel Thibault
Andrew Okonya
Design Overview: Hardware

• Adafruit Feather M0 Adalogger
• MCP9808 High Accuracy I2C Temperature Sensor Breakout Board
• Adafruit BME280 I2C or SPI Temperature Humidity Pressure Sensor
• Adafruit Precision NXP 9-DOF Breakout Board
• ADXL377 - High-G Triple-Axis Accelerometer
Design Overview: LiDAR

- **Theoretical Design will consist of the following:**
  - Laser
    - VCSEL capable of measuring CO2, CH4 or H2O at a wavelength between 1600-2100 nm
  - Scanner and optics
  - Mirror
    - Target is to eliminate this component using synthetic array LiDAR techniques
  - Photodetector and receiver electronics
    - Minimal data processing conducted within main payload.
Design Overview: Ports

- Request for multipurpose/ atmospheric port with 9 pin connector:
  - 1 pin 5 volt for camera
  - 1 Vcc power pin for LIDAR
  - 1 Ground pin
  - 4 LIDAR Data pins
  - 2 pins unused
Design Overview: Payload Layout

- LiDAR and Camera will be mounted to the multipurpose port.
- Not planning on using Makrolon plates at this time.
- Electronics, power, and life science experiment will be mounted to top and bottom of canister.
Functional Block Diagram: Mechanical

- Top of Canister
  - Geiger Counter

- Multipurpose Port
  - LIDAR Camera

- Bottom of Canister
  - Electronics, Power
  - Life Science Experiment
Design Overview: Payload Layout

- Geiger Counter
- Camera
- LIDAR
- Electronics, Power
- Life Science Experiment
- Multipurpose Port
- Canister
Design Overview: Port Diagram

- Design in event of single port award
Design Overview: Shared Can Logistics

• Sharing can with ASU and Phoenix-based community colleges
• Plan for collaboration
  – Communicating via email and text messaging
  – Sharing designs using an online Trello project board
Project Management

Name of Presenter(s)
Andrew Okonya
Management

• Team organization chart
  – Integration Team (UA and ASU)

<table>
<thead>
<tr>
<th>Team Member</th>
<th>Role/Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andrew Okonya</td>
<td>Team Leader</td>
</tr>
<tr>
<td>James Cook</td>
<td>ASU Team Lead</td>
</tr>
<tr>
<td>András Szép</td>
<td>Camera Lead</td>
</tr>
<tr>
<td>Márton Szép</td>
<td>Camera Lead</td>
</tr>
<tr>
<td>Duffy Elmer</td>
<td>Life Sciences Lead</td>
</tr>
<tr>
<td>Shobitha Jillella</td>
<td>Life Sciences Lead</td>
</tr>
<tr>
<td>Joel Thibault</td>
<td>Electronics Lead</td>
</tr>
<tr>
<td>Steve Smith</td>
<td>Mechanical Lead</td>
</tr>
<tr>
<td>Cathy McIntosh</td>
<td>Software Lead</td>
</tr>
</tbody>
</table>

– Community college sub-teams will be formed during CDR
• Preliminary schedule for the semester

<table>
<thead>
<tr>
<th>Event</th>
<th>Date(s)</th>
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<tbody>
<tr>
<td>CoDR Teleconference</td>
<td>10/11/2017</td>
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<tr>
<td>Earnest Payment of $1,000 Due</td>
<td>10/13/2017</td>
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<td>UA and ASU group meetings on Preliminary Design</td>
<td>10/14/2017 – 10/30/2017</td>
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<tr>
<td>AZSGC Progress Update Telecon</td>
<td>10/20/2017</td>
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<td>AZSGC Preliminary Design Review Teleconference</td>
<td>10/30/2017 - 11/3/2017</td>
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<td>UA and ASU Individual Group Meetings on Critical Design</td>
<td>11/4/2017 - 12/3/2017</td>
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<td>Community College Introductory Meetings</td>
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<tr>
<td>AZSGC Progress Update Telecon</td>
<td>11/16/2017 - 11/20/2017</td>
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Management

- Monetary budget
  - Travel (For integration team)

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<tr>
<td>Additional Member Fee</td>
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<tr>
<td><strong>Total Per Student</strong></td>
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Management

• Team mentors
  – **Dr. Jekan Thanga**, Assistant Professor, Head of SpaceTREx Laboratory, University of Arizona
  – **Dr. John Scott Wilbur**, Associate Professor of Microbiology, University of Arizona
  – **Dr. Thomas Sharp**, Professor, School of Earth and Space Exploration, Arizona State University
## Team Contact Matrix

<table>
<thead>
<tr>
<th>Team Member</th>
<th>Role/Position</th>
<th>Email Address</th>
<th>Phone Number</th>
<th>US Person? (Y/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andrew Okonya</td>
<td>Team Leader</td>
<td><a href="mailto:aokonya@email.arizona.edu">aokonya@email.arizona.edu</a></td>
<td>520-360-2803</td>
<td>Y</td>
</tr>
<tr>
<td>James Cook</td>
<td>ASU Team Lead</td>
<td><a href="mailto:jrcook5@asu.edu">jrcook5@asu.edu</a></td>
<td>480-298-7160</td>
<td>Y</td>
</tr>
<tr>
<td>András Szép</td>
<td>Camera Lead</td>
<td><a href="mailto:andrasszep@email.arizona.edu">andrasszep@email.arizona.edu</a></td>
<td>520-33169-11</td>
<td>N</td>
</tr>
<tr>
<td>Márton Szép</td>
<td>Camera Lead</td>
<td><a href="mailto:szepmarton@email.arizona.edu">szepmarton@email.arizona.edu</a></td>
<td>520-331-0702</td>
<td>N</td>
</tr>
<tr>
<td>Duffy Elmer</td>
<td>Life Sciences Lead</td>
<td><a href="mailto:duffy.elmer@gmail.com">duffy.elmer@gmail.com</a></td>
<td>830-570-4288</td>
<td>Y</td>
</tr>
<tr>
<td>Shobitha Jillella</td>
<td>Life Sciences Lead</td>
<td><a href="mailto:sjillella@email.arizona.edu">sjillella@email.arizona.edu</a></td>
<td>623-628-8175</td>
<td>Y</td>
</tr>
<tr>
<td>Joel Thibault</td>
<td>Electronics Lead</td>
<td><a href="mailto:jthibault@email.arizona.edu">jthibault@email.arizona.edu</a></td>
<td>520-490-8090</td>
<td>Y</td>
</tr>
<tr>
<td>Steve Smith</td>
<td>Mechanical Lead</td>
<td><a href="mailto:ssmith77@email.arizona.edu">ssmith77@email.arizona.edu</a></td>
<td>520-975-6248</td>
<td>Y</td>
</tr>
<tr>
<td>Cathy McIntosh</td>
<td>Software Lead</td>
<td><a href="mailto:crmcintosh@email.arizona.edu">crmcintosh@email.arizona.edu</a></td>
<td>480-650-7590</td>
<td>Y</td>
</tr>
<tr>
<td>Sean Hopta</td>
<td>Member</td>
<td><a href="mailto:shopta@asu.edu">shopta@asu.edu</a></td>
<td>480-543-7014</td>
<td>Y</td>
</tr>
</tbody>
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- Entire integration team (members with lead in their position) will need Dropbox access
- Contact matrix will be changing once community college members are added after PDR
Team Availability Matrix

- Matrix of times during the week when the Team is available

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<th>Wednesday</th>
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Conclusion

• Overall team missions are to:
  – expand digital **camera stabilization technology**
  – measure **ionizing radiation**
  – observe radiation effects on **bacteria and immune cells**
  – measure **atmospheric data** using a low-cost **LiDAR system**

• Issues and Concerns:
  – LiDAR experiment is still conceptual
  – Currently researched techniques could be difficult in port
  – Atmospheric port access selection

• Looking Forward:
  – Explore LiDAR capabilities with other subjects through published research
  – Finalize Geiger counter design and implementation
  – Explore lifecycle of life science experiment and use mount for ASCEND launch to confirm stability