Biological Acquisition Unit

Team Members:
Alex Lieu
Atiyyah Muhammad
Matthew Walters

Advisors:
Dr. Helferty
Dr. Silage
Outline of Presentation

Mission Overview
- Objective
- Theory
- Background/Previous Research
- Biological Analysis
- Success Criteria

Design
- Constraints
- Design Process
- System Architecture
  - Electrical System
  - Filtration System

Management
- Team Members
- Advisors
- Budget Outline
Mission Overview

- Collect biological samples at different altitude levels of the Earth’s atmosphere to be analyzed and researched by our biology department
- Measure the flight dynamics of the rocket (spin rate, acceleration etc.)
- Measure the strength and direction of the Earth’s magnetic field
Mission Overview

**Theory**

- **IMU** – (Inertial Measurement Unit) is a device which consists of a gyroscope and accelerometer which will measure the rocket’s flight dynamics. This unit will help determine what type of samples we are collecting at what altitude.

- **Filtration System** - collects organic and inorganic material suspended in the upper atmosphere.

- **Magnetometer** - will be used to measure the Earth’s magnetic field.
Background

- Microbes can interact with their high-altitude environment; they can become the nucleus for rain drops and snow flakes and influence the amount of precipitation that falls.

- The upper atmosphere is one of the most UV intense environments on Earth; the survival mechanisms of some microbes can enhance the understanding of the possibility of other life forms outside of our planet.

- Microbes in the atmosphere can travel long distances, and can possibly give insight on global warming, climate changes and movement of diseases.
In 2011, scientists identified over 2,800 bacterial species that were deposited onto Mt. Bachelor, Oregon during two trans-Pacific dust plume events.

The long-range transport and surprising level of species richness in the upper atmosphere changes traditional thought patterns in aerobiology.

Future research aimed at understanding how bacteria can survive at high altitudes could become essential in the fields of biotechnology and medicine.
Mission Overview

Expected Results

**Filtration System**
- Collect a statistically significant sample to compare to previous studies
  - Amount of samples
  - Type of microbes

**IMU (Inertial Measurement Unit)**
- Accurately and reliably record data such as:
  - Velocity/Acceleration
  - Flight Dynamics
  - Gravitational Force

**Magnetometer/Spectrometer**
- Study magnetic field in upper atmosphere
- Study intensity of UV rays in upper atmosphere
- Compare experimental magnetic field to actual values
**Constraints**

**Weight:** The canister must not exceed $20 \pm 0.2$ lbs.

**Distribution of weight:** The center of gravity should lie within the $1 \times 1 \times 1$ cubic inch of the geometric center of the payload canister.

**Dimensions:** **Maximum:** height is 4.75 inches and maximum diameter is 9.3 inches.

**Power:** Only after takeoff is power to be active.

**Battery:** No lithium rechargeable batteries.
Design

System Design
• Schematics
• Coding
• Product Placement

Components (Active Circuits)
• Accelerometer
• Gyroscope
• Magnetometer
• Voltage Regulator
• Microprocessor

Components (Passive System)
• Filters
• Filter Paper
• SD Reader

Assemble Design
• Combine components of active circuit with passive system

Results
• Retrieve stored data
• Test biological samples

Design Test
• Meet specifications and requirements
• Test filtration system
Power

Basic System Requirements

- Pic32 Chipkit Microprocessor – 90 mA | 3.3 V
- Triple Axis HMC5883 Magnetometer – 0.9 mA | 3.3 V
- Gyroscope – 3.5 mA | 5 V
- XY-axis accelerometer – 15 mA | 6 V
- Z axis accelerometer – 2.5 mA | 6 V
- Parallax Standard Servo motors- 15 mA | 6V
- Total – 29.6V

Sources

- Voltage regulators will be used to maintain the proper amount of power for each sensor
- Series of 9 V batteries will power system
System Architecture

Battery → RBF wiring → G-Switch → Voltage Regulator

ChipKit PIC32 Micro Controller

Key
- Power
  - 36V
  - 6V
  - 5V
  - 3.3V
- Data

IMU

Magnetometer

Servo for Filtration System Valves

Storage
Design

- Flash Memory: 512K
- RAM Memory: 128K
- Operating Voltage: 3.3V
- Operating Frequency: 80 MHz
- Typical Operating Current: 90 mA
- Input Voltage: 7 to 15V
- Input Voltage (maximum): 20V
- I/O Pins: 83
- Analog Inputs: 16
- Analog Input Voltage Range: 0V to 3.3V
- DC Current Per Pin: +/- 18 mA
- I²C and SPI interfaces
**Design**

**Triple Axis Magnetometer HMC5883**

- Power: 2.16 to 3.6 V
- Field Range: +/- 4 Gauss
- Current: 0.1 mA
- Bandwidth: 10 kHz
- Weight: 50 mg
- I²C interface
Atomic IMU – 6 Degrees of Freedom

Design

ADXRS649 Gyroscope
- Power: 4.75 V to 5.25 V
- Range: +/− 20,000 °/sec
- Current: 3.5 mA
- Bandwidth: 2 kHz
- Weight: 0.5 g
Atomic IMU – 6 Degrees of Freedom

Design

ADIS16204 XY-axis accelerometer
- Power: 3.0 to 3.6 V
- Range: +/- 37 g
- Current: 12 mA
- Bandwidth: 400 Hz
- Serial Peripheral Interface (SPI)

ADXL001 Z-axis accelerometer
- Power: 3.3 to 5 V
- Range: +/- 70 g
- Current: 2.5 mA
- Bandwidth: 22 kHz
Parallax Standard Servo Motor

Design

• Weight 1.55 oz (44 g)
• Power Requirements: 4 to 6 VDC*,
• Pulse-width modulation
• Operating temp range: +14 to +144 °F (-10 to +50 °C)
• Torque: 38 oz-in @ 6 V
Filter System

Design
- There is two ports
  - Inlet (Dynamic)
  - Outlet (Static)
- Four inline filters

Mass Flow
- The Mass flow depends on pressure difference
- An oblique shock positioned just before port determines pressures
  - Dynamic – stagnation pressure
  - Static – static pressure

Testing
- Tubing, fittings, and filters will be autoclaved (~150°C)
- Two filtration systems will be constructed in order for biologist to know origins of particles trapped

Exposure Time
- System is
  - closed altitude < 30km
  - Open altitude > 30km
- Estimated time of exposure: 5 minutes
Management

Team Members

Alex Lieu (ECE)
• Team Leader
• Microprocessor
  • Data Acquisition
  • Power

Atiyyah Muhammad (ECE)
• Hardware
  • Magnetometer
  • IMU
  • Power

Matthew Walters (ME)
• Filtration System
• Center of gravity testing
• Mass flow rates
## Budget Outline

<table>
<thead>
<tr>
<th>Parts</th>
<th>Manufacture</th>
<th>Cost</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payload Canister</td>
<td>-</td>
<td>$7,000</td>
<td>1</td>
</tr>
<tr>
<td>ChipKit Max 32</td>
<td>Microchip</td>
<td>$50</td>
<td>1</td>
</tr>
<tr>
<td>Magnetometer</td>
<td>Honeywell</td>
<td>$20</td>
<td>1</td>
</tr>
<tr>
<td>G-Switch</td>
<td>Digikey</td>
<td>$13</td>
<td>2</td>
</tr>
<tr>
<td>SD card 16 GB</td>
<td>SanDisk</td>
<td>$28</td>
<td>1</td>
</tr>
<tr>
<td>SD reader</td>
<td>Microchip</td>
<td>$38</td>
<td>1</td>
</tr>
<tr>
<td>¼” NPT Valve</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Filter canister</td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Filter Paper</td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>IMU</td>
<td>Sparkfun</td>
<td>$124.95</td>
<td>1</td>
</tr>
</tbody>
</table>
Conclusion

Issues
• Integrating the filtration system with canister
• Control system for valves on the filtration system.

Concerns
• Properly sterilizing the filtration system.
• Transporting the samples back to Temple University.

Future Plans
• Order parts: Microprocessor, IMU, and magnetometer.
• Design, build, and test the filtration system.