Near Space Exposure of Microbes

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High Altitude Balloon Team, Space Technologies at Cal

Introduction

On March 4th, the High Altitude Balloon team at STAC launched our first high altitude balloon, and more importantly, we launched two experiments - one for the Koskella/Lindow labs at Berkeley, and one for NASA JPL. More details about the experiment are below, but this launch was the first step for STACâĂŹs overall goals with the High Altitude Balloon team. We want to create a program to work with Berkeley community to launch all sorts of experiments to high altitudes, but most importantly, we want to launch experiments like this one to help further space exploration.

The Experiment

Two bacteria were exposed to the stratosphere: *P. syringae* and *P. xerothermodurans*, each for its own reason.

P. syringae is a bacteria that is known to be transported through the atmosphere, hitching a ride on dust particles or water droplets. It is an ice nucleating bacteria, which means that it can form raindrops or snow at temperatures above what one would normally expect. Thus, it has been implicated in weather formation. Understanding how the bacteria changes in an extreme atmospheric setting can help us understand how the bacteria survives its journey.

P. xerothermodurans was isolated from a spacecraft assembly clean room by NASA. Px is a hardy, endospore forming bacteria that is hard to kill. These traits make it a threat to âĂIJplanetary protectionâĂİ, the protection of foreign planets from contamination from Earth organisms. By understanding how Px responds to a Mars-like environment, we can better predict the bio-burden future spacecraft will carry on journeys outside LEO.

The Payload

The payload consisted of the exposer and the electronics to collect data and ensure successful operation of the exposer. Our onboard embedded system was controlled by an Arduino Mega based on the ATmega2560 chip. Our onboard sensors included a thermocouple temperature sensor, pressure and temperature based altimeter, UV sensor, and Tracksoar GPS sensor. We also had a data logging system that used an SD card on FAT32 and a Real Time Clock. Our system communication protocols were SPI and I2C.

We utilized two linear servos to expose our bacteria at two different altitudes as determined by our onboard altimeter. These actuators ran on a timed power transistor in case of retraction failure and were actuated by PWM signals. The actuators held our bacteria coupons via a custom designed and 3d printed in PLA bacteria coupon holder.

For visual logging, a canon powershot A3100 ran an intervalometer script using the canon hack development kit to prolong battery life and maximize video and photo collection of the biological experiment as it is exposed to the atmosphere.

Balloon Recovery Methods

We used a Tracksoar GPS module running on the APRS network at a frequency of 144.39 MHz as our primary means of telemetry. Live GPS coordinates of the balloon were transmitted via an externally-mounted half-wave dipole antenna. APRS repeaters picked up the balloonâĂŹs APRS packets and relayed them via aprs.fi servers where we tracked the balloon in real-time. We also directly received and demodulated APRS packets ourselves using RTL-SDR dongles and GQRX.

Once the balloon landed, we had a secondary transmitter blasting the balloonâĂŹs GPS location at 434 Mhz via a half-wave whip antenna that was mounted in a more secure area of the payload. The chase team was equipped with highly directional Yagi antennas that were used to home in on the final landing location of the balloon.

Biological Prep

P. syringae samples were plated onto coupons in sterile water and left in stasis for 14 hours. The water evaporates, leaving desiccated bacteria on the aluminum coupon surface. Coupons were attached to bioexposure payload minutes before flight.

Launch Day

We launched from Sugarloaf Open Space in Walnut Creek CA at 9:30 AM. The balloon stayed aloft for approximately two hours and popped above Modesto CA. It landed near the highway in a cherry blossom grove. Upon recovering the box, it was discovered that the exposer for exposing bacteria at 90,000 feet was intact, but the 35,000 feet exposer was missing, presumably having broken off during the flight. The launch was declared a relative success!

Launch Results

Bacteria from the 90,000ft actuator were aseptically transferred to sterile containers and transported back to lab for further analysis. We reached a peak altitude of 31054.84m at a relatively constant ascent rate of 4.75m/s. We collected relatively good altitude and pressure data during the entire flight. We collected temperature data from a thermocouple as well.

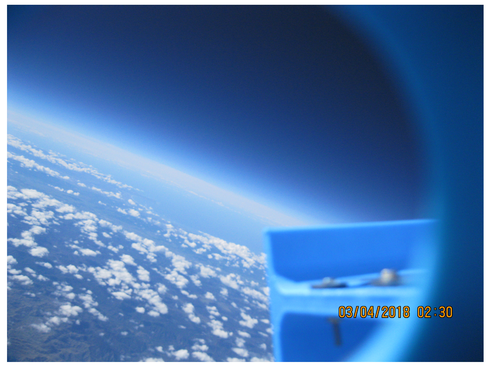

Figure 1: An image of our payload at 45000 feet altitude with the 35000 feet payload exposed.

Experiment Conclusion

The flight hardware was a sterile-enough environment that flight samples were not contaminated by outside sources. Preliminary tests of P. syringae viability show a significant loss of culturable cells between experimental and control cases. At this time we cannot attribute this cell death to freezing/thawing, high radiation, or atmosphere rarefaction. Future flights will be measuring UV radiation in hopes of elucidating which specific factors are most important in bacterial survivability.

Improvements

Listed below are some improvements that are being made for future launches

- Develop our own HAB Shield for the Mega and place sensors on there, instead of soldering onto a protoboard
- Add individual power-cycling functionality to all peripherals and actuators
- Add an inertial measurement unit (IMU: accelerometer/gyro)
- Test the electronics in low-pressure and low-temperature environments
- Protect the electronics with acrylic housing
- Replace the thermocouple with an ambient temperature sensor
- Add multiple cameras to the payload

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