Colorado Space Grant Consortium

DEMOSAT

M.O.S.T.

Monkeys Observing Space Temporarily

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CCD Balloon-Sat Spring 2015 Team

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Mission Overview:

Our team objective was to design and build an atmospheric planet analysis-collection computer (A-PACO). A-PACO will collect data from the atmosphere. This includes temperature, humidity, pressure, and various hydrocarbon sensors. Also, during the flight there will be a data collection from motion sensors, as well as documentation of the flight (Pictures/Video).

In addition, another objective will be to capture an atmospheric air sample at an altitude of at least 80,000 feet. This sample will be analyzed for physical composition, and hydrocarbons.

Requirement Flowdown

•Our payload was expected to withstand the extremely cold temperatures of the stratosphere, as well as maintaining its structure after free-fall while keeping all electrical components secure and fastened as required.

•Mass was not to exceed 1.5 kilograms

•Two computers were to record data from seven different sensors.

•Two cameras would watch the upper and lower angles to document launch, flight, and descent.

Experiments

•Test for temperature, humidity, pressure at the edge of space inside and out outside payload

•Testing for hydrocarbons and carbon monoxide at different altitudes

•Testing the movement of the payload box while in flight with 3-axis

•Refine air sample experiment

•Acquire flight documentation with photo equipment

• Utilize the memory on board of the ATMega328 to store some data from the sensors to create a "Black Box"

Payload Shell

The Payload design was a Decahedron. This shape is similar to a soccer ball and has a more even weight distribution so the payload would roll on impact and be less likely to burst at its joints. The payload was designed with foam core.

Parts List

Part	Manufacturer	Model
2 Arduinos	Smart Projects	Arduino Uno (ATmega328)
Air Sample Collection Container	Cel Scientific Corp.	Tedlar Bag 0.5 liters
Air Pump	Honeywell	N/A
Batteries	Sparkfun	Po-Li 2000mAh
HackHD Camera GoPro	HackHD GoPro	1080p HackHD Hero 3
2 Humidity Sensors	Sparkfun	HIH-4030
2 Temperature Sensors	Sparkfun	DS18S20
Methane Sensor CO2 Sensor	Sparkfun	MQ-4 MQ-7
2 SD-Card Shields	Sparkfun	SparkFun microSD Shield

Budget

All parts listed plus some misc. expendables $670

Management

Our team changed members several times during the initial phase of the project, however our final team worked together in order to put together our project under the time constraints and suiting the requirements. While the people listed were the primary handlers of each part of the project, there was overlap from all members as the project developed.

Scheduling and Presentation: Addiel Orozco, Zophie Prystalski

Box Design: Chris Dellacroce, Zophie Prystalski, Nizeimana Emmanuel

Software: Addiel Orozco, Chris Dellacroce & Zophie Prystalski

Hardware: Addiel Orozco, Chris Dellacroce & Jordan Thompson

Assembly: Everyone

Testing: Everyone

Test Plan & Results

Verification Tests:

Verification of all the sensors was performed throughout the stages of the construction of the payload, as the sensors were added into the payload. For the CO_2 sensor we used our breath to test and received a small plateaued rise while the air was moving across and then dipped back to the background levels once stopped. The temperature sensors were verified with the heat from a finger and returned the subjects temperature accurate. When the inside and outside humidity sensors were installed, they were tested the same as the CO_2 with breath, producing a spike. The CO was tested with a lighter and a large spike was recorded. The 3 axis was tested with one meter movement along the x, y, and z with accurate readings recorded. The air sample test was simply making sure the air pump was powered and would trigger.

Drop Test:

The drop test was performed at the Confluence Building at CCD. During this test the payload box containing the board and electrical components descended in free-fall for the distance of approximately 130 ft. off of the Confluence building. The landing surface for the drop test was concrete. This test was repeated twice more and after examination following the test minimal structural damage was found, and the whole board and components responded appropriately to the software testing. There were no reportable incidents before, during, or after this test.

Kick Test:

A kick test was conducted to really make sure that a hard landing would not affect the equipment onboard. The payload was kicked as hard as possible and hit a metal pole, this is the only time the outside took any notable damage, but when opened the inside components were unaffected.

Whip Test:

For the whip test we strung up the payload to a cord from a previous flight and sung it over head for 30 seconds. A second whip test was done that included sharp changes to the direction of swing and instant stops of swing. All whip tests were positive outcomes with no movement or detachment from the cord.

Pressure Testing:

The pressure test was performed at CU Boulder. During this test the components and Arduino were subject to pressure conditions similar to those experienced at 100, 000 feet for 10 minutes. After the conclusion of this test a visual examination of the components and solder joints did not yield any signs of structural failure. In addition, all the sensors were examined by running the software and comparing readings against a calibrated source. No reportable incidents occurred during or after this test.

Temperature Testing:

The Temperature test was done to see if we could prove that the payload does not need heaters. Our payload, with some sensors running, was taking to the National Ice Core Lab and placed inside their large freezer and kept at -40 C for one hour. When the payload was retrieved from the freezer the sensors were still running and the batteries had a minimal amount of condensation on them. With these results we did decide to fly the payload without any heaters.

All parts were tested and ensured to be working before our launch date, April 11, 2015.

Launch & Recovery: Successful

Before the flight the payloads were arranged horizontally on the ground. Consequently they were attached to a string, which connected the payloads in the following order: parachute, beacon and the cord holding the payloads. On top of the parachute, there was an area in where the balloon was going to be connected prior to launch. When everything was set for take-off, it was moved to an empty field in where the balloon was filled with hydrogen and connected on top of the parachute. Our payload was on flight #208 which took place on Saturday April 11, 2015, in Eaton, Colorado, at 6:00 am. The balloon ascended right away; contrary of what we expected, which was that it would take a while to ascend and gather speed. When the balloon reached approximately 98,000 feet in altitude, due to the change of atmospheric pressure the balloon went kaput. The payloads were in free-fall for about 10 min, afterwards the parachute deployed, allowing a more controlled descent. It also made it more difficult for us to predict where our payload would land, because any slight change on the wind current, would take it in a different direction. After driving an hour and a half in pursue of our payload, it finally touched ground. The first thing we did after recovery was an initial examination to assure that our payload did not present any external damages and we secured the bag containing the air example. The SD cards that contained the flight data were extracted and the files were later uploaded to a computer. We proceeded to check the camera SD cards that contained the video files taken from the flight. To our misfortune the SD cards was unable to record droning flight. That event made it impossible for us to obtain the information.

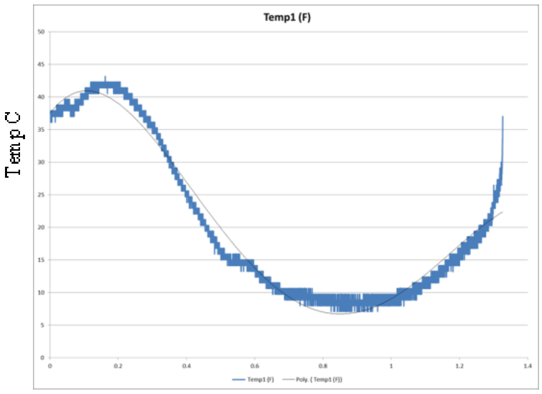
Results and Analysis:

After the recovery of the payload the SD cards with the data were analyzed as well as all the components used during the flight. However, after initial inspection, it was noticed that the cables supplying power to one of the Arduinos got disconnected. This Arduino had the shield with the circuitry for the air sample. For this reason an air sample was not obtained during this flight. However, there was data obtained from the other sensors.

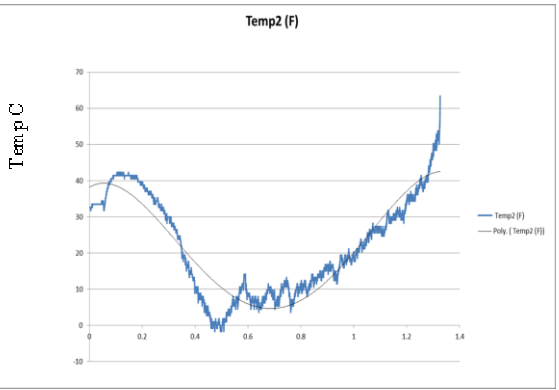
Temperature sensor:

The data from the temperature sensor was retrieved from the SD card and plot against time. The temperature sensor worked as expected and the data correlates with data from other similar flights. The data is displayed in graphs A and B, below:

(A)



(B)



The data in graph A was taken on the inside of the payload and the data in graph B was taken on the outside of the payload.

Humidity sensor:

The data from the humidity sensor was retrieved from the SD card and plot against time. The humidity sensor worked as expected and the data correlates with data from other similar flights.

3-Axis sensor:

The data from the 3-Axis sensor was retrieved from the SD card and plot against time. The #-axis sensor worked as expected. However, the data obtained is in the form of raw data from the sensor. This data has been hard to interpret and especially because it is the first time that anyone on this team has tried to plot this data in a form of a 3-D graph.

CO_2 sensor:

The data from the CO_2 sensor was retrieved from the SD card and plot against time. The CO_2 sensor worked as expected and the data is being interpreted for correlation with other known data to see if the data is valid.

CO sensor:

The data from the CO sensor was retrieved from the SD card and plot against time. The CO sensor worked as expected and the data is being interpreted for correlation with other known data to see if the data is valid.

Black Box experiment:

The data from the Black Box experiment sensor was retrieved from the Arduino itself, and stored to a SD. The experiment worked as expected and the data correlates with data from the SD card used to store the flight data.

Air sample:

The air sample failed to a loss of power. During the analysis of the data from the SD card placed on the Arduino that was on control of the shield for the air sample; it was determined that the loss of power happened about 10 minutes after launch. It is recommended that for future tries, it would be better to control the mechanism of the air pump by a separated Arduino. This could be accomplished by using an Arduino-mini to reduce weight and better power connections.

Radioactivity Testing:

Adriana Solano Designed an Performed a Radioactivity Test on this flight. In the experiment she designed a method to discriminate between three types of radioactivity exposure while in flight: β, α, and γ particles. Her entire write up, including results, is attached as appendix A.

Final Comments:

Highlights for this seasons launch were the development of a new method to probe radioactivity, we flew a successful mission without heaters, We proved yet another variation of a polygonal shape which displayed exceptional structural integrity and we had success with keeping many of our sensors powered up from launch through landing.

We look forward to the next flight to further our development of the radioactivity testing protocol to analyze alpha particles in addition to beta and gamma. We also have not successfully videotaped a full trip in our last two outings. We seek to continue the development of our air sampling techniques which we did successfully achieve on the Fa 14 flight.

We are also grateful to NASA and Colorado Space Grant Consortium for the opportunities that they have allowed us to pursue.