Colorado Space Grant Consortium

DemoSat
Design Document

ACES
Aerogel Cube Environmental Studies

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1.0 ACES Mission Overview

Design and manufacture a balloon payload to measure the effectiveness of aerogel and analyze if the upper atmosphere environment has an effect on lunar simulant.

Aerogel

Use an Aerogel Thermal blanket to protect an Arduino with a multitude of sensors and a Geiger counter that will take flight in the payload.

- The goal is to see if an Aerogel thermal blanket is a valid protector against radiation and if it can be a viable source to use for future missions as an insulator for hardware and livable habitats.

Regolith

ACES will observe if a near-space environment affects the mechanical properties of lunar regolith simulant and compare it to regolith tested on earth.

The microstructures of the samples will be examined before and after the exposure using optical microscopes for the pore size distributions and any damage development such as microcracks.

The reason why ACES decided to choose this specific experiment was that we originally planned an experiment that could benefit in any way understanding Mars or come up with an idea that could benefit humans in Mars exploration in some way. Aerogel is an up-and-coming insulator that is being used in the space industry. It was used in the Mars rover, Pathfinder, and is being used as an insulator in the new space suits to protect against radiation and temperature.

However, Lunar Relogith Simulant was placed within the payloads but the team has not received any word on the analysis for the samples.

2.0 Requirements Flow Down

Primary

Launch two payloads, one with thermal aerogel blanket and one control satellite.

Primary

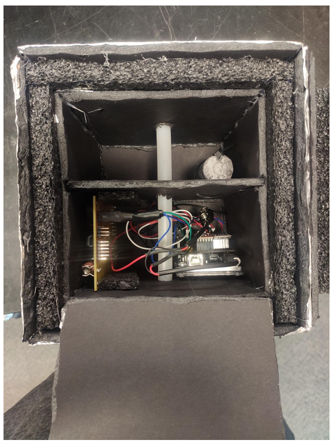
Determine if thermal aerogel blanket is a proper insulator against temperature and radiation.

Primary

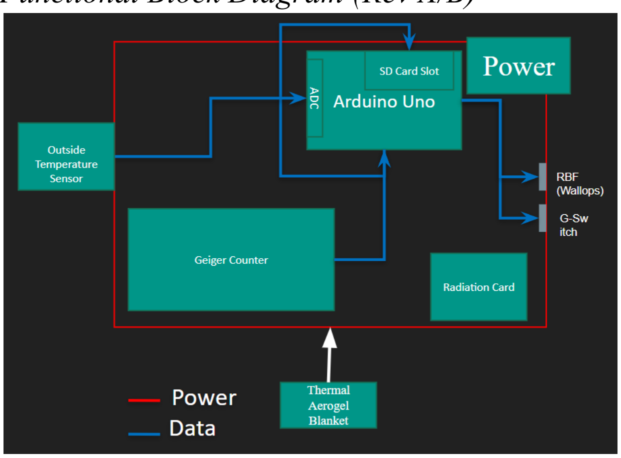
Compare samples of regolith that has been exposed to a near-space environment to samples that have been kept on the surface of Earth.

3.0 Design

After we figured out what we wanted our mission to be, the next step was to design the payload. There was already a kit with most of the sensors that were required, but we had to buy the aerogel blanket and the geiger counter separately. Due to the flakiness of the blanket, we decided to create a smaller enclosure inside of the larger one, with the insulation in between. We further separated the smaller compartment in half, one to hold the radiation card and the regolith, and the other to house the sensors and the arduino. The sensors all fit nicely together on top of the Arduino, but we had to extend the cables for the external temperature sensor because at first it was not long enough. In order to comply with the requirements of the DemoSat program, we looked at examples of other DemoSats and used the testing criteria that previous teams had used. We constantly kept in mind the weight limit throughout the design process, which led to a payload that was very light.



Functional Block Diagram (Rev A/B)



Parts	Quantity	Supplier	Price($)
Aerogel Thermal Blanket - 6mm	1	BuyAerogel.com	$150
MightyOhm Geiger Counter	2	Amazon.com	$200
Radiation Card	2	Amazon.com	$33

		Total	$383

4.0 Management

1	**Structures**					
1.1	Designing New Skeleton	Caedin, Manas	1/27/22	1/31/22	4	100%
1.2	Skeleton and Foam Fitting	Caedin, Manas	2/1/22	2/10/22	9	100%
1.3	Preliminary Skeleton and Justify Design Choice	Caedin, Manas	2/4/22	2/16/22	12	100%
1.4	Finalization of Structure and Begin Building	Caedin, Manas	2/4/22	2/16/22	12	100%
1.5	Complete Structure	Caedin, Manas	2/18/22	03/11/22	21	100%
1.6	Testing Structure	Caedin, Manas	2/25/22	03/15/22	18	100%
2	**Electronics**					
2.1	**Power**					
2.1.1	Power Budget	Caedin, Manas	1/31/22	2/4/22	4	100%
2.1.2	Narrow Down Battery Choice	Caedin, Manas	2/1/22	2/11/22	10	100%
2.1.3	Integrate Power System	Caedin, Manas	2/25/22	3/15/22	19	100%
2.3	**Wiring**					
2.3.1	Design wiring layout	Caedin	2/25/22	3/15/22	19	100%
2.3.2	Solder the components and assemble	Caedin	2/25/22	3/15/22	19	100%
3	**Software**					
3.1.1	Code Arduino	Addie & Majo	1/23/22	1/28/22	5	100%
3.1.2	Test Arduino Sensors	Addie & Majo	1/23/22	2/4/22	12	100%
3.1.3	Solder Geiger Counter	Addie & Majo	1/31/22	2/4/22	5	100%
3.2.1	**Code Geiger Counter**	Addie & Majo	1/31/22	2/10/22	10	100%
3.2.2	Test Geiger - battery and calibration	Addie & Majo	2/18/22	3/4/22	14	100%
3.3	**Make sure all sensors are working properly**	Addie & Majo	2/6/22	3/15/22	37	100%
4	**Flight Readiness**					
4.1			2/4/22	3/18/22	42	90%

5.0 Budget

Parts	Quantity	Supplier	Price($)
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		Total	$383

Total Budget was $500, and we had used up a total of $383. Leaving the team with $117 to spare.

Weight

Both payloads came out to be 580 grams. The Lithium battery was 45 grams and the regolith that was included in the payloads was about 40 grams.

9V battery weighs 46 grams.

Regolith will weigh about 40 grams.

Estimated weight as of right now is 580 - 600 grams

6.0 Test Plan and Results

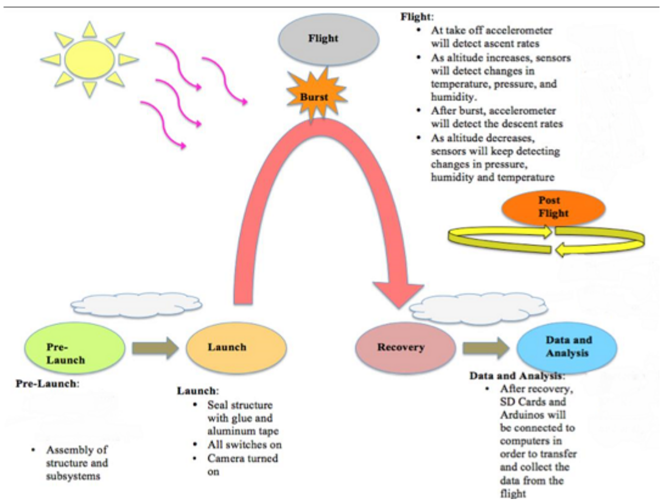
We followed the test plan specifications laid out in the “Demosat Testing Procedures” document. We followed the test plan which included the Preliminary Whip Test, The Flat Sat Test, The Cold Test, The String-Up Test, The Shake Test and The Functionality Test except for The Drop Test because we were short on time. The testing allowed us to fix issues that would have caused a failure during launch- first and foremost being the alkaline battery. The battery we were using did not survive the temperature test. We rectified this by replacing the battery with a lithium battery. The whip test proved that the components and flight tube were secured. There were also software issues that we discovered and fixed, such as the geiger counter not recording its output to the same CSV file as the other sensors.

7.0 Expected Results

After performing tests for the temperature sensors, batteries and Geiger Counters, we have concluded that in order to be powered for the duration of the flight lithium batteries must be used in replace of the alkaline batteries. According to our research, we expect the external temperature sensors to read as low as -60 degrees Fahrenheit as the altitude increases within the troposphere, and then begin to increase up to 5 degrees Fahrenheit as the payload rises within the stratosphere. It is expected that the internal temperature sensor will read lower for the aerogel blanket insulated payload compared to the control payload, To test the Geiger counters we performed many tests using a radioactive cup that was held at a constant distance from the aerogel and polyethylene payloads. We compared the counts per minute of each Geiger at from the same distances. Testing of the Geiger counters showed that we should expect a difference in counts per minute of beta and gamma radiation between the aerogel and polyethylene foam insulated payloads, as our data showed that there were more counts per minute detected by the polyethylene Geiger than the aerogel Gieger We are hoping that this will tell us that the aerogel blanket is a better insulator of temperature and radiation than the polyethylene foam.

8.0 Launch and Recovery

The entire team was there at launch, and retrieval went smoothly with no visible damage to the payloads, in fact, the payloads were still running at recovery. The entire flight string was laid out in a row. The recovery could not have gone better. The payload was successfully retrieved with the data in it . We used a radiation card as a backup in case the geiger counter failed, but it was not needed because the geiger counter worked as expected for the entire duration of the flight. The prior testing that we had conducted showed that the payload would most likely survive the landing.

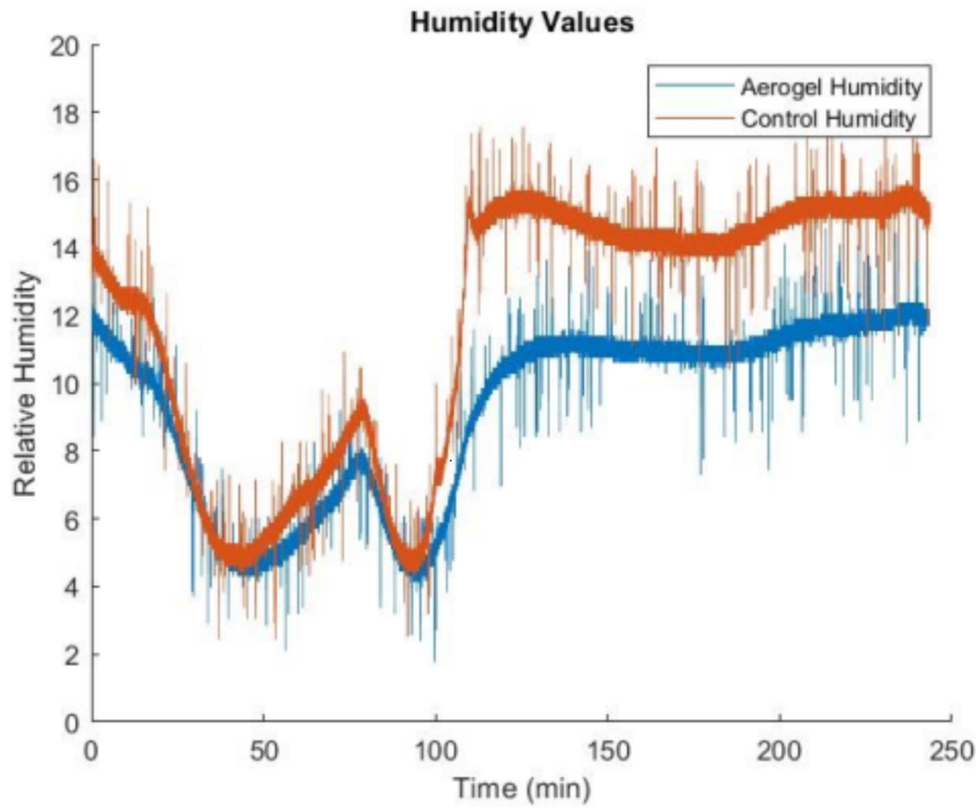


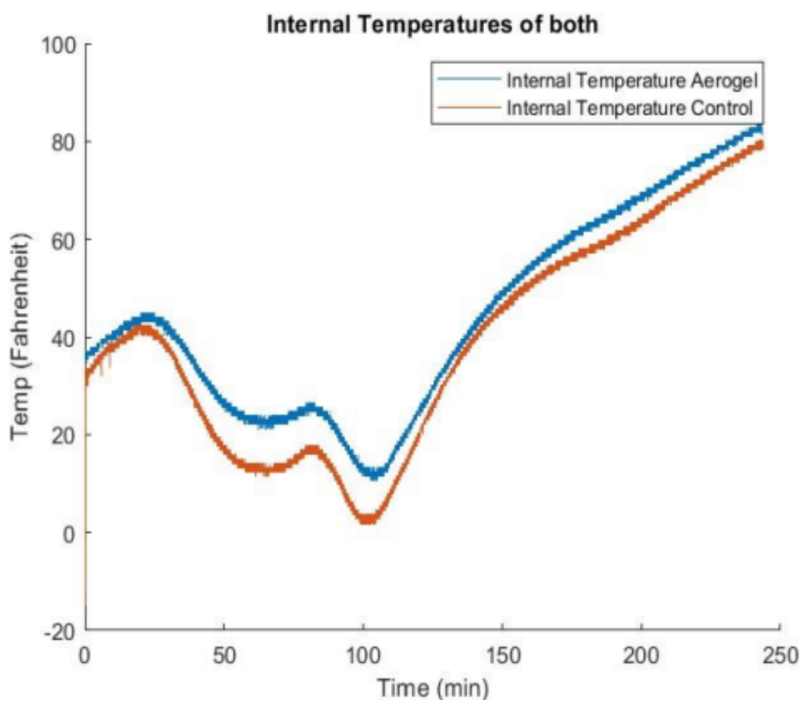
9.0 Results, Analysis, and Conclusions

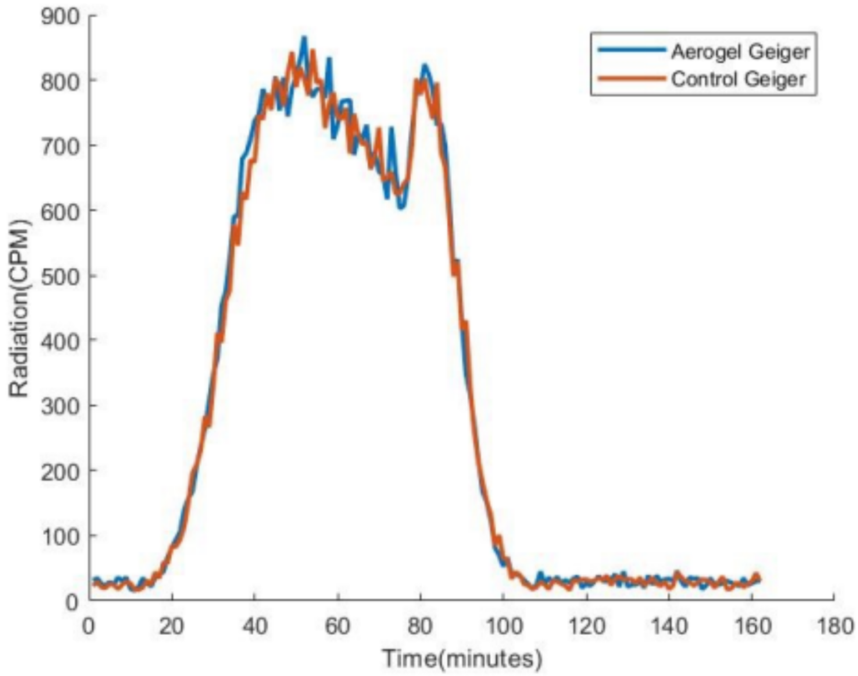
After retrieving the data we have created plots of our results collected from the flight. Our peak altitude was 96,000 feet before descent. Our results have proved that the aerogel thermal blanket was successful in holding the humidity levels lower than the polyethylene foam. You can see the trend of the graph change as the payload ascends through the thermosphere up to the stratosphere. Descent began approximately 80 minutes into the flight.

According to the data during flight, there was not a significant difference in radiation detected between each payload, resulting in a conclusion of the aerogel blanket not sufficient to the polyethylene foam in beta and gamma radiation protection. There was a noticeable difference in the temperature insulation between payloads. The aerogel blanket was able to keep the internal of the payload an average of 5 degrees Fahrenheit warmer than the polyethylene.

ACES determined that the aerogel thermal blanket is a good insulator to use in place of polyethylene foam. Although it is more expensive, it is able to help protect the sensors within the high altitude balloon payloads, which could be worth the extra cost in order to collect successful data. An aerogel thermal blanket may not be as successful to solely be used to insulate a future habitat on the lunar or Martian surface as well as a spacesuit given its lack of radiation protection.


Humidity Values
Aerogel Humidity
Control Humidity
Relative Humidity
Time (min)
20
18
16
14
12
10
8
6
4
2
0
0
50
100
150
200
250


Internal Temperatures of both
Internal Temperature Aerogel
Internal Temperature Control
Temp (Fahrenheit)
Time (min)
100
80
60
40
20
0
-20
0
50
100
150
200
250



10.0 Ready for Flight

Upon retrieval of the payload, the team noticed no damage had occurred to both the payloads. Resulting in both payloads being ready to be used for flight at any given moment again. The only item that would need replacing is the lithium battery to ensure it has enough power to last a full flight once again. The payload is powered on using a switch that turns on the entire system, which includes the arduino and Geiger Counter. The payloads should be stored in a safe spot, out of the way so it doesn't get knocked over since there are Geiger tubes inside and those are very fragile. If the tubes are broken then the Geiger Counter is not ready to use.

11.0 Conclusions and Lessons Learned

In conclusion, we learned that an Aerogel Thermal blanket purchased from Aerogel.com was not a successful shield against radiation exposure, however, was successful in keeping the inside of the payload warm.

12.0 Message to Next Year

To future students participating in the DEMOSAT program, the launch date sneaks up on you. Remember to plan accordingly and allow yourself to have more time than you think you need because you never know when something unexpected might happen. It is key to communicate with all your team members and make sure everyone is on the same page.

One of the things that we discovered was that with a lithium battery and the dual-layer design of our payload we did not need a heater inside, and the payload remained warm enough to operate all components successfully.