Colorado Space Grant Consortium

DEMOSAT 2010
DESIGN DOCUMENT

Team SkyHawk

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Revision A/B

Table of Contents

1.0 Mission Overview

We at Fort Lewis College are studying the amount of shielding that the atmosphere provides the Earth, using a Geiger counter for radiation and a set of photodiodes in conjunction with cameras to study the ozone, and collecting the data using a micro computer that we hope to optimize for future launches.

The primary objective of our flight is twofold; to glean knowledge from the experiments that are on the payload, and also to continue to develop our payload and technology for future years. We hope to make it so that in the future, groups can start off with our Pico ITX boards, a micro-computer that is onboard the payload, and not have to do a lot of prep work to make them function in any way that they'd like. We'd also like to clean more knowledge about how the atmosphere shields the earth from harmful things such as radiation and UV light.

The experiments that we are conducting revolve around two new components, a Geiger counter, and a couple of photodiodes. We plan to use the Geiger counter to measure the difference in radiation as we travel through the atmosphere, discovering how much the atmosphere shields us. We expect to find much higher counts at high altitude where there is very little atmosphere.

We already have a couple of cameras from previous flights, and we hope to use the cameras in conjunction with the photodiodes to discover more about the atmosphere's shielding effects, specifically the ozone. One of the photodiodes will be a control, just monitoring light, while the other will have a narrow band filter monitoring a certain band for ozone. The camera's will be taking images and perhaps short videos to use in conjunction with certain data that is measured, to put a picture to what our graph is showing

We already have pressure and temperature sensors that will also be running to further add to the data we collect from the other new sensors. One of the things that we are refining that was from a previous flight was an accelerometer. We hope to make the data that we collect from the accelerometer more meaningful. Also, we are planning to use a WiFi card to remote access the unit to set it up before flight.

2.0 Requirements Flow Down

The primary requirement of our project stems from our want to collect atmospheric data throughout the flight. We want to compare the data that we collect to that of the standard data that we got on the ground. To aid the progress of this we must go through certain steps for each component so that we can collect data at the level that we would like to.

Level 0: -Get Pico ITX up and running.
Level 1: -Install OS on board and make sure that it is functioning smoothly.
-Make sure board can be powered by battery; commence battery testing.
-Perform cold testing.
-Install board into structure, connect all sensors to it.
-Commence testing procedures for strength, impact, etc.

Level 0: -Design structure that will contain each testing component and the main computer.

Level 1: -Test carbon fiber to see if it will be a suitable material

-Build individual containers for each component.

-Test each component container for impact, etc.

-Build total structure, test.

-Layer with insulation before launch, make sure insulation is suitable.

Level 0: -Measure alpha and beta radiation throughout the flight.

Level 1: -Get Pico ITX computer up and running.

-Get Geiger counter to interface with computer, power up, etc.

-Integrate into the structure.

-Make sure all the devices can be powered on at once.

-Pass testing procedures, for environment, impact etc.

Level 0: -Get photodiodes and cameras running to collect information throughout flight.

Level 1: -Get photodiodes that will work for our testing procedure.

-Build circuit boards to facilitate data collection.

-Make new circuit boards interface with computer or HOBO.

Make sure all components have enough power.

-Integrate components into our structure.

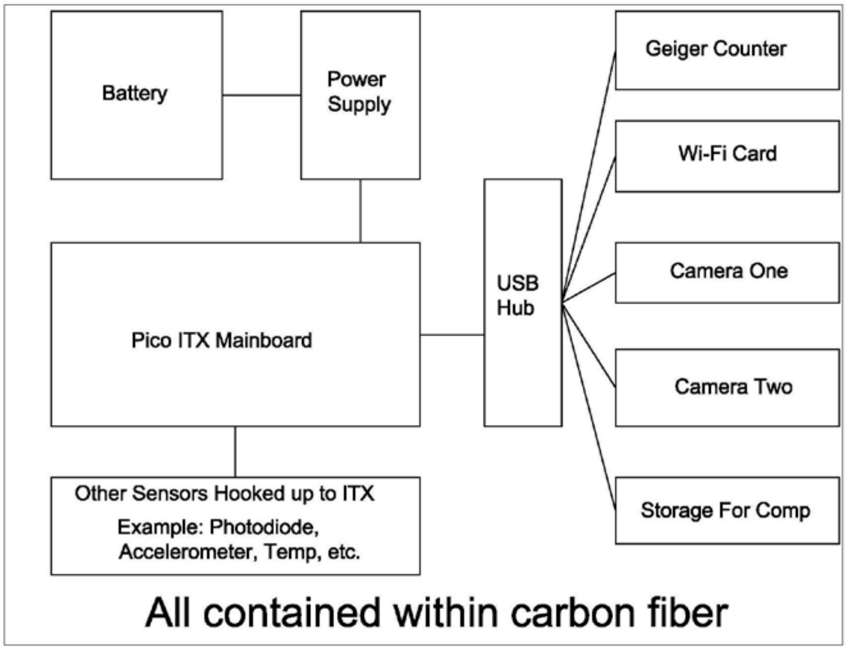
Level 0: -Get all other sensors up and running, such as accelerometer, etc.

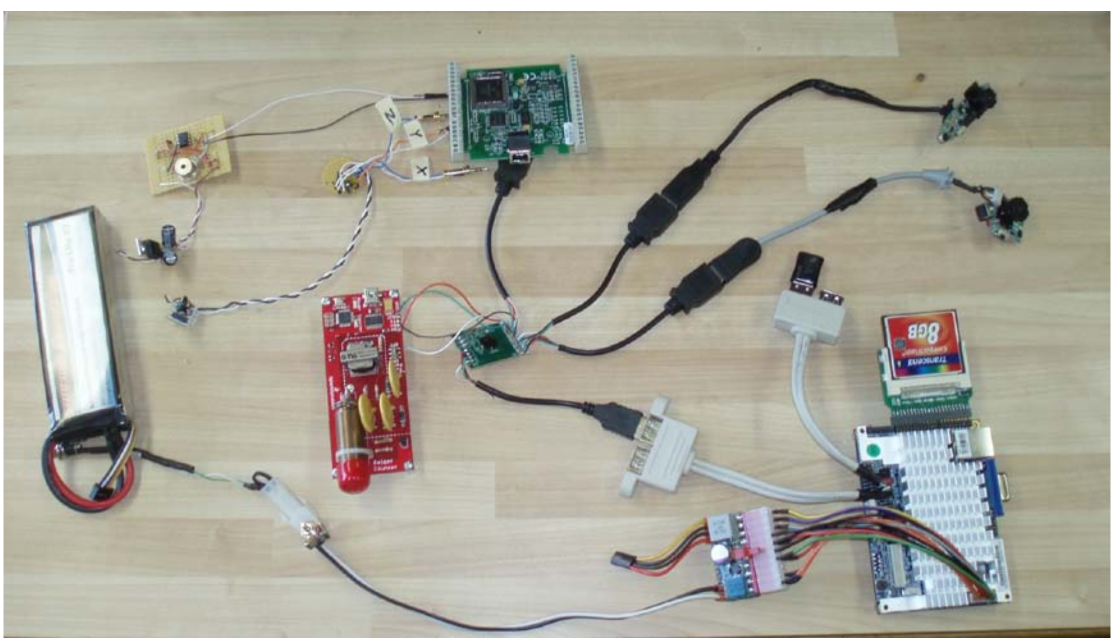
Level 1: -Connect them to circuit boards to facilitate collecting data.

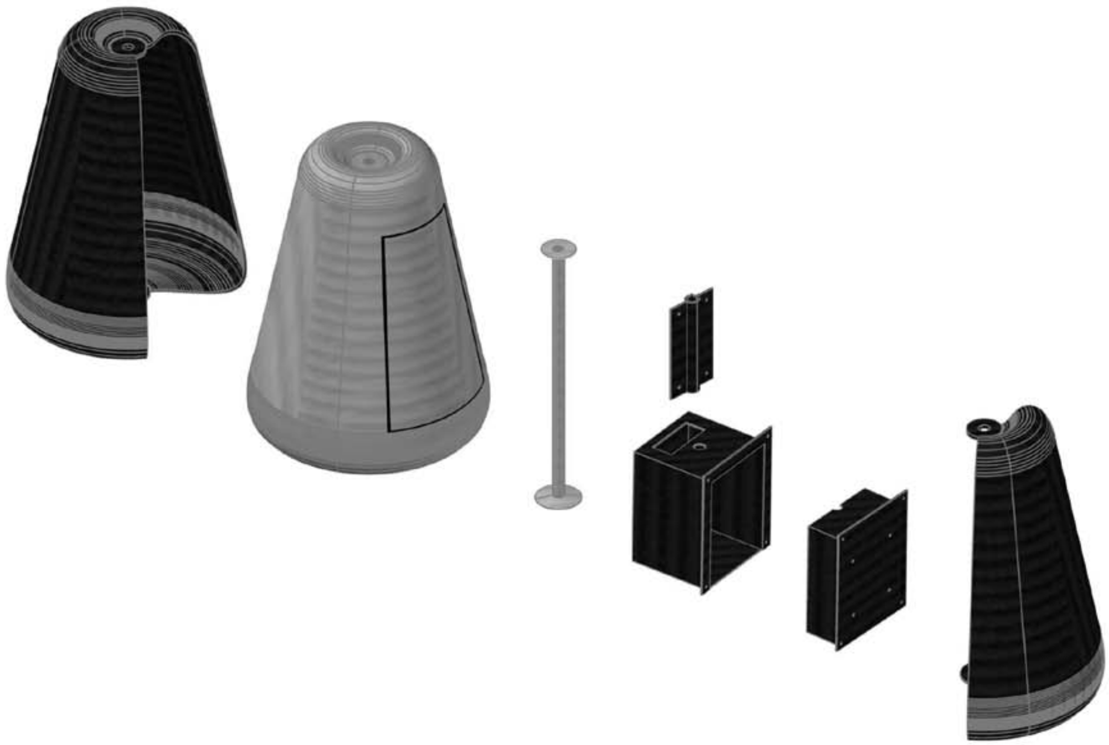
-Build them into the structure.

-Commence testing procedures for strength, impact, etc.

3.0 Design


Battery
Power Supply
Geiger Counter
Wi-Fi Card
USB Hub
Camera One
Pico ITX Mainboard
Camera Two
Other Sensors Hooked up to ITX
Example: Photodiode, Accelerometer, Temp, etc.
Storage For Comp
All contained within carbon fiber





Above is a preliminary design. We will be keeping weight down by encasing this in carbon fiber as opposed to a heavier metal. The Pico ITX will interface with all the devices that use USB. If we can and time allows, we will make an interface from the ITX board to the other sensors, as opposed to using HOBO data loggers to log those sensors data.

Parts:

- Pico ITX Board/Power Supply/Accessories
- Transcend Compact Flash hard drive
- Buffalo N-Series WiFi card
- Geiger Counter
- Photodiodes
- Accelerometer
- HOBOs potentially for certain data logging
- Electrify Power Series lithium polymer battery
- USB hub
- Carbon fiber shell
- Some sort of insulation

Requirements:

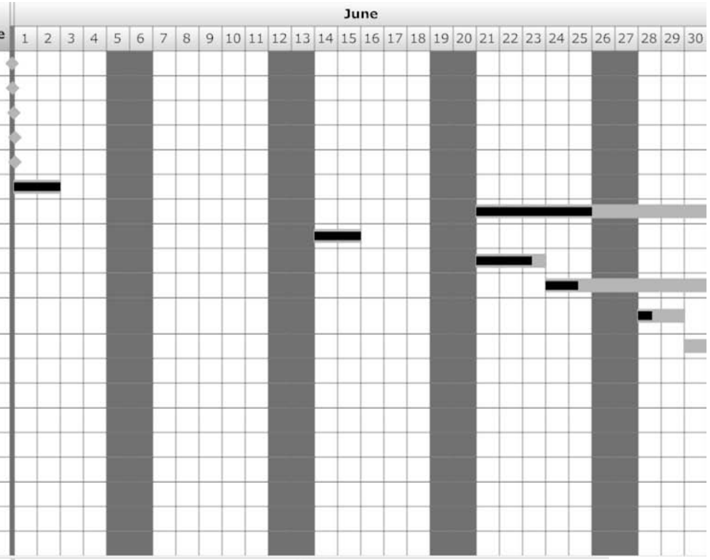
We will be meeting the requirements for testing by using a combination of high strength carbon fiber for strength and the Pico ITX and lightweight sensors to keep the weight to a minimum. The ITX board should run well at low temperatures, and the battery will be wrapped with a material from the heat sinks on the ITX board to transfer some heat and keep the battery temp at an optimal level.

4.0 Management

Our team is comprised of three members and an advisor, each with separate responsibilities, but primarily we work together as a team. We will split things up as a leader, and two workers. The leader will also contribute to both members projects, but the responsibility will lay with the individual to finish certain parts.

Team Member	**Role**	**Primary Responsibility**
Chris Hardrick	Team Leader/Circuitry	Time Management, Overall project status, Circuit planning for sensors
Peter Samuelson	Software/ITX	Software and developing the ITX platform, interfacing with the sensors
Travis Lange	Hardware/Sensors	Sensor interaction, how the sensors read, data interpretation
Dr. Charles Hakes	Teacher/Supervisor	Watches over the entire program, keeps track of progress.

Number	Task	Start	End	Duration	% Complete
1	Idea Planning	5/7/2010	5/15/2010	6	100.0
2	Research	5/10/2010	5/11/2010	2	100.0
3	Part List	5/18/2010	5/19/2010	2	95.0
4	OS	5/25/2010	5/26/2010	2	100.0
5	Battery Test	5/25/2010	5/26/2010	2	100.0
6	Camera Test	5/31/2010	6/2/2010	2	100.0
7	Carbon Mold	6/21/2010	6/30/2010	8	50.0
8	Carbon Test	6/14/2010	6/15/2010	2	100.0
9	Geiger Counter	6/21/2010	6/23/2010	3	80.0
10	Essential ITX	6/24/2010	6/30/2010	5	20.0
11	Sensor Construction	6/28/2010	6/29/2010	2	30.0
12	Sensor Testing	6/30/2010	7/1/2010	2	0.0
13	Sensors	7/2/2010	7/2/2010		
14	Build Structure	7/4/2010	7/6/2010	2	0.0
15	Structure	7/6/2010	7/6/2010		
16	Compile Payload	7/7/2010	7/8/2010	2	0.0
17	Test	7/8/2010	7/16/2010	7	0.0
18	Testing	7/16/2010	7/16/2010	1	0.0
19	Analyze and Repair	7/16/2010	7/28/2010	9	
20	Launch	7/31/2010	7/31/2010		



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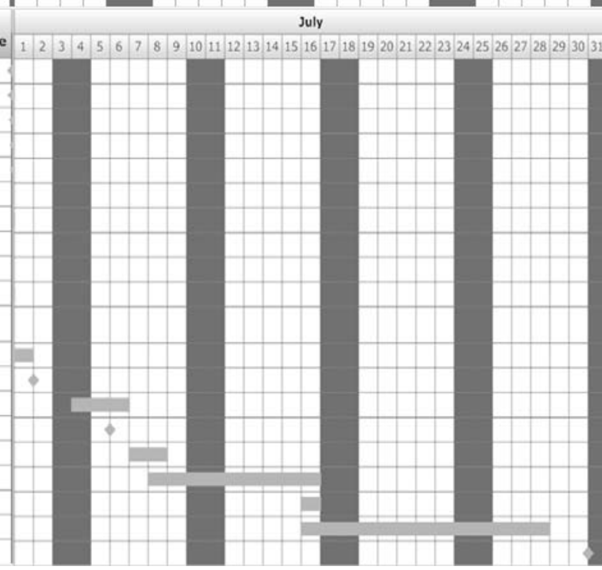


5.0 Budget

We currently have a budget of $1000 to spend on parts and components. Most of the components we are reusing from last year, such as ITX board and some of the sensors. Most of the money that will be used in the budget will be on things that we might want to replace or update, and new sensors. The carbon fiber will also take a significant chunk of the budget.

For the weight issues, as we proceed we will weigh all the sensors and components to make a list of how much it weighs and what we have left weight wise to add. The project that was launched last year contained all of our components in a much heavier structure, so preliminarily we should have extra weight to add more sensors to the board.

Item	Use of Item	Cost Allocated/Actual Cost	Weight Allocated/Actual Weight
Pico ITX	Micro Computer/Storage	Owned	
Hard Drive	OS location	Owned	
Thumb Drive	Storage of data	Owned	
Camera 1	Taking images	Owned	
Camera 2	Taking images	Owned	
Battery	Powering Unit	Owned	
Accelerometer	Taking data for movement.	Owned	
Photodiode(s)	Taking narrowband data	$10/25	
Circuit Boards	Collecting data from diodes	$100/100	
Geiger Counter	Collecting alpha/beta information	$150/150	
Carbon Fiber	Structure	$250/300	
Additional Sensors/Repairs	Anything else we need	$490/410	TOTAL MASS: 1658

6.0 Test Plan and Results

Testing:
We plan on doing testing in many different stages. The first tests that we are planning on doing comprise of the ITX board's ability to run multiple USB devices and what the processer can handle. Also we will be conducting battery testing to see how long the battery will last and the actual mAh that it produces. We will then repeat these tests in a deep freeze state to see how they run at very low temperatures. We will also test out the functionality of remote accessing the unit with Wi-Fi to start our systems and boot up.

We will then proceed to start integrating the different parts of our project together so we can design a case out of the carbon fiber. The carbon fiber we will test before we build a case out of it to even see if the strength that it displays is one that we will work with our designs and the needed strength that we have Once the case is designed, we will proceed to do some basic structural testing on the case, drop, whip and stair without the payload inside, just weight. If the carbon fiber seems to have survived, we will repeat these tests with the actual payload inside after proceeding to do a deep freeze test on the unit as a whole.

Balloon SAT Summer 2010 Test Procedures

Test Subject	Step ID Number	Procedure
ITX Boards	1	Get the ITX Boards and all the components
	2	Hook the USB cables to one of the ITX Boards
	3	Put the compact flash reader on a ITX Board
	4A	Turn on one ITX Board
	4B	Turn on the other ITX Board
Cameras	1	Get the cameras
	2	Make sure the wires are still connected
	3	Plug the cameras into the USB ports
	4	Find cameras on the ITX Board
	5	Check how much RAM is being used while both run
	6	Change the frame rate from 33 fps to 16 fps
	7	Repeat step 5
Geiger Counter	1	Obtain the Geiger Counter
	2	Plug the Geiger Counter into a USB port
	3	Make sure the Geiger Counter works on the ITX Board
	4	Calibrate the Geiger Counter with test capsules
Carbon Fiber Mold	1	Get the Carbon Fiber material and resin
	2	Pick a shape for your mold
	3	Mold the Carbon Fiber into desired shape
	4	Find a tall building and drop mold off the building
	5	Find some stairs and kick mold down the stairs
	6	Hook the string to the mold and drag it around
Battery	1	Get the battery and charger for the battery
	2	Hook the battery up to the charger
	3	Hook a (fill in the blank) ohm resistor to the battery
	4	Repeat step 3 with a (fill in the blank) ohm resistor
	5	Repeat step 3 in a freezer at -5 degrees Celsius
	6	Repeat step 3 in a freezer at -40 degrees Celsius
	7	Repeat step 3 in a freezer at -80 degrees Celsius
	8	Repeat step 4 in a freezer at -5 degrees Celsius
	9	Repeat step 4 in a freezer at -40 degrees Celsius
	10	Repeat step 4 in a freezer at -80 degrees Celsius
	11	Repeat step 3 in a vacuum
	12	Repeat step 4 in a vacuum

Test Subject	Step ID Number	Procedure
ITX Board w/ Battery	1	Hook the battery up to the ITX Board
	2	How long the battery lasts with everything running
	3	Run steps 1 and 2 again in a freezer at -5 degrees Celsius
	4	Run steps 1 and 2 again in a freezer at -40 degrees Celsius
	5	Run steps 1 and 2 again in a freezer at -80 degrees Celsius
	6	Run steps 1 and 2 again in a vacuum

7.0 Expected Results

There are a few things that we expect to figure out on our current mission. We have many different sensors running, so we will include for each sensor/project what we expect to discover and see.

Photodiodes:

Preliminary:

The photodiodes are for finding out more about the effects of the atmosphere on shielding us from UV rays and what the difference in altitude means for levels of ozone.

Actual: Got voltage readings in the lab from sunlight outside. We expect to see the difference in the amount of UV radiation at higher altitudes corresponding to a higher voltage.

Geiger Counter:

Preliminary:

The Geiger counter is something that we are hoping to use to discover the effect of our atmosphere as a shield against radiation. We know that the atmosphere blocks many particles from reaching us, but we are curious to see the level's of radioactive particles and how much larger the counts get in a higher atmospheric setting.

Actual: We never fully tested the geiger counter until flight. A broken geiger tube interfered with out data. However, we did manage to get some preliminary voltage readings to show that it was functioning, just not correctly. We expect to see voltage changes signaling shifts in the amount of solar radiation.

Accelerometer:

Preliminary:

The accelerometer is to discover how the balloon and string move in flight, helping us discover how the spin affects the sensors and how much movement is encountered when the balloon bursts or the payload impacts the ground.

Actual: Since the USB Daq failed in testing, we decided to remove the accelerometer. The data wouldn't have been able to be collected using the methods that we had as backup, as we found out from some testing in the lab.

Cameras:

Preliminary: The cameras are to be used to take images to correspond to our other experiments. Since we should have synchronized timing on all the parts, we should be able to relate a picture to a certain UV level from the photodiode, or when we got a large count on the Geiger counter. Also the cameras will be used for video to see movement from the balloon, much like the accelerometer.

Actual: After testing, the camera's were decided to be used to take video of the flight, and not conduct any measurable testing. The camera's couldn't be fully powered by the ITX board, so any measurement procedure would have had a very large amount of random error inherent.

8.0 Launch and Recovery

Launch: Upon arrival, we plan to turn on our ITX board and access everything through a crossover cable. The crossover cable will allow us to access our ITX board without having to use a wireless router or a computer monitor. All of our temperature and pressure circuits are on hobos that have been programmed to start monitoring things as of 7:00A.M. Saturday July 31st.

Recovery: For recovery we plan on following all of the directions that NASA gives us. We are expecting a safe landing even if the parachute happens to not open. After recovering our payload, we plan on taking it back to Durango and seeing what results we got from all of our electronics.

Day of launch: The launch was a success. We turned on all that needed to be turned on. The cameras were working and the hobos were set to go off just before launch. During the flight, the parachute deployed properly but the balloon stayed attached to the parachute causing the payloads to fall pretty fast and hit the ground hard. All of the equipment in our payload was unharmed in the fall.

9.0 Results, Analysis, and Conclusions

The data that we collected was a mixed bag of things. We will start by discussing the video camera data and the ITX boards tasks.

We expected to collect data that was set on a schedule, predetermined many days before the launch. When we lauched the ITX board, things seemed to start fine. Until after the launch and recovery, we didn't discover that somehow four of our nine video files had become corrupted by battery failure. During testing, only one would be become corrupted by battery failure. This was different during the actual run, however.

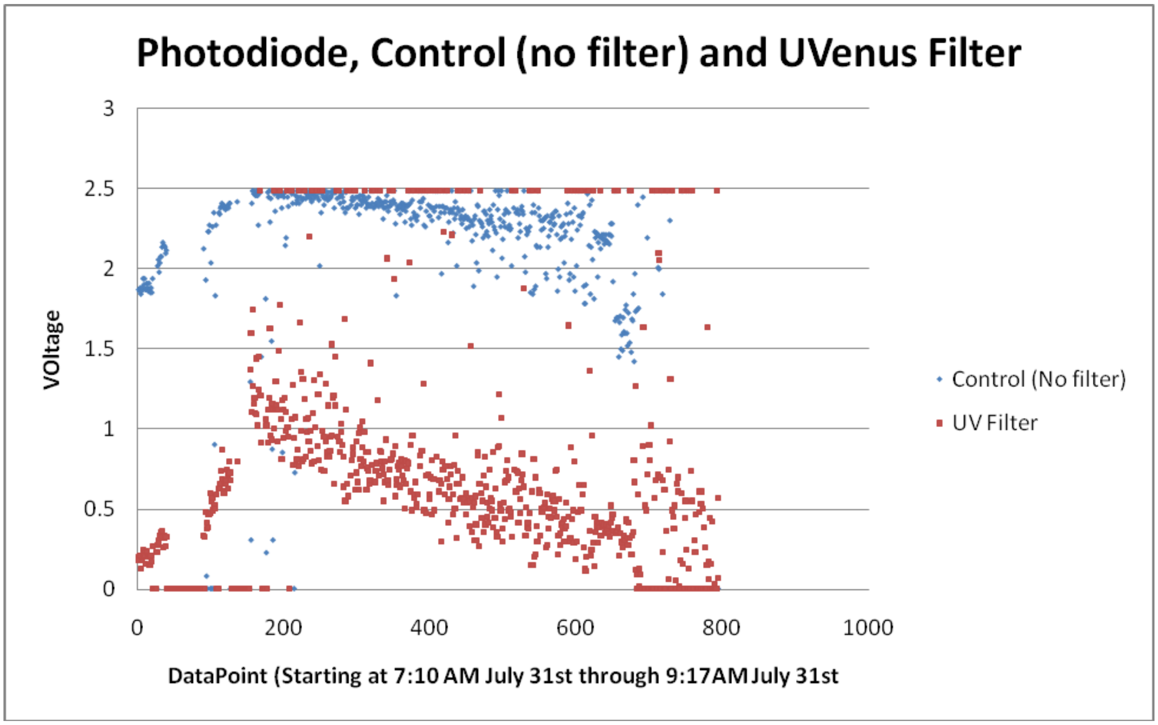
Here are some selected images from our video. All images were taken in the visible light spectrum.

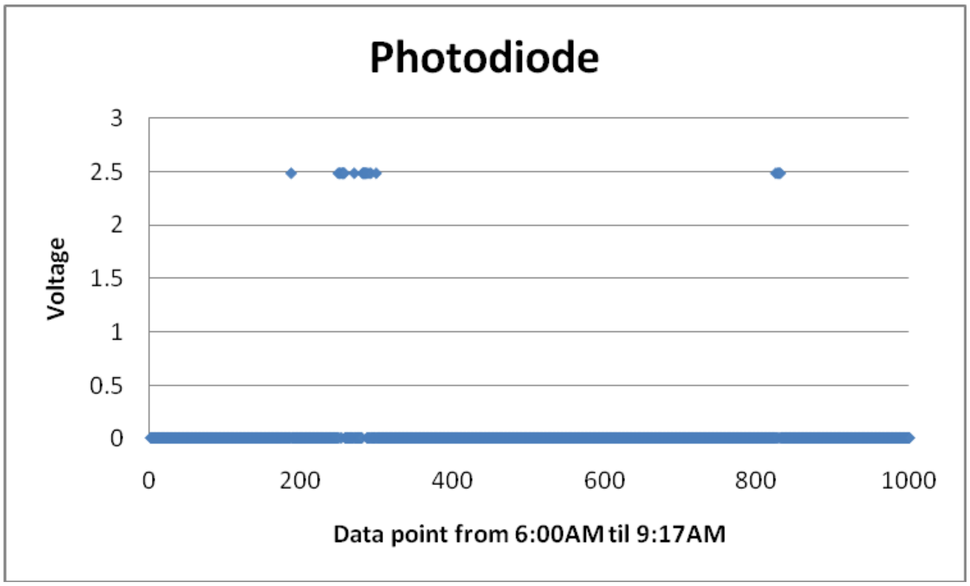
As you can see from the video images, the sun washes out most of the color. But in the third image we saw a recurring whitish object on the horizon, or above the horizon. Potentially a star or planet, maybe a satellite.

Next, We have the data from the photodiode with the UVenus filter, and the photodiode without it that we were using for control.

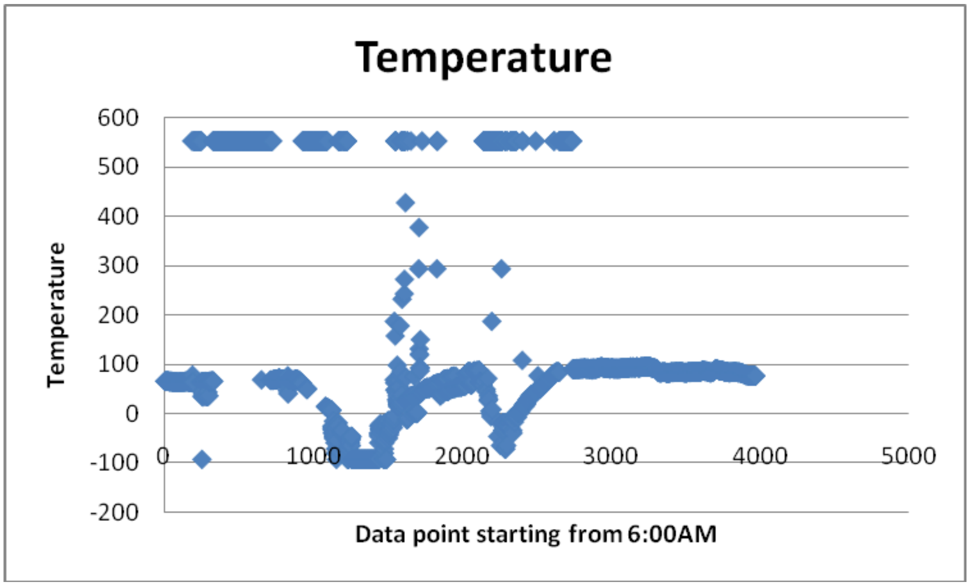
As you can see from the below data, as we went up higher the voltage readings on the diodes dropped. This is what we expected to see, as there is less atmospheric reflections, so the light would only hit the filters less often.

However, we didn't expect to see such a drop in the amount of UV rays. The control seems to drop with a curve, while the UV drops very linearly. This is not what we expected. However, as corrected by the total amount of light, the UV light become much greater at a higher altitude.

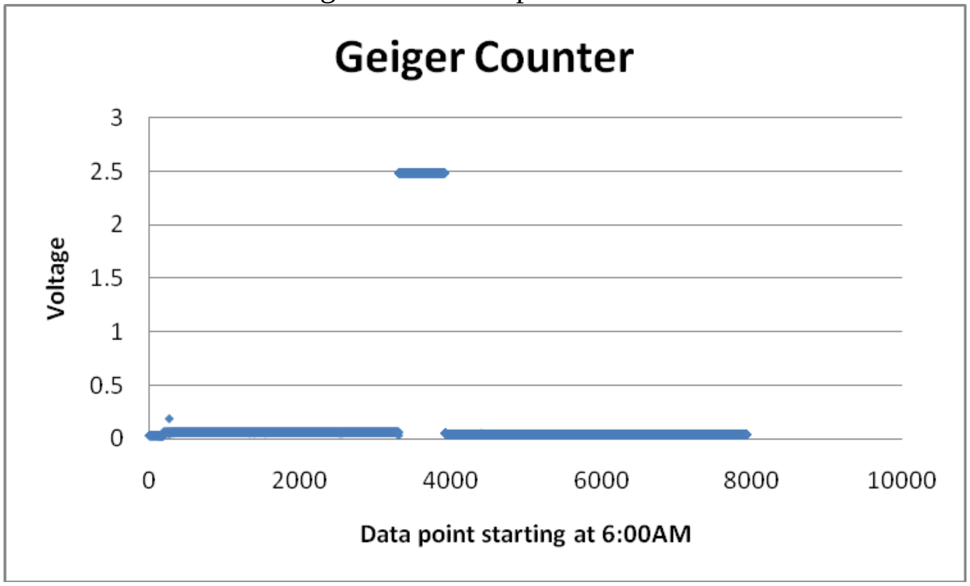




We think that the photodiode failed due to the hobo because it mostly gave back zeros. This seemed to happen with all of the hobos that we had in place. It could have happened during mid flight because all of them were working before we sent them up.



This is our data from our photodiodes. It reads our the temperature as the altitude increases. We don't know exactly how or why the temperature goes so high. It could have been when the sun was directly on it at it's highest point. We did expect the temperature to fall drastically below zero because it was so high in the atmosphere.



We feel that the geiger counter failed due to the hobos as well. We really didn't get any high voltages back until after we recovered the payload. The time of the high peaks were at 10:51AM. Maybe this happened right before the highest point on the payload but we are uncertain. It would make some sense if it was almost completely out of the atmosphere but we think it was a false reading from the hobo.

10.0 Conclusions and Lessons Learned

We as a team learned a lot about how errors can throw off your planning. When we started, we had a much larger, grand project planned. By the end, however, we had scaled it very far back. Even then we had many issues during the flight with our data, and also with our ITX board. The ITX board, though a powerful tool, isn’t strong enough to take data from two video cameras. This data collection procedure just corrupted much of our video files.

We also learned that the best way to compensate for unplanned errors is to always have a backup plan. We had the HOBO’s ready to go in case the USBDaq failed, and when it did we were ready. We also had a backup plan for the Geiger counter, if it didn’t run through the computer to figure out a way to hook it up to a circuit so we could at least collect data. However, the Geiger counter proved to be more than we bargained for, and the data we collected from it was basically nonsense. It seemed to collect the same amount of hits every ten seconds, which it shouldn’t have with such a large change in elevation.

All in all, we really learned a large amount about everything from project planning to digital logic. The software hurdle was a large thing to overcome with such an underpowered computer, and perhaps a more powerful computer or a different angle would have been beneficial.

11.0 Message to Next Year

The ITX board is a miniature computer, not a full powered desktop or even a very underpowered laptop. If you must use it, use it only to collect raw data. Video overloads the computer and it consumes power.

The USB daq is a powerful tool, use it. The software works great, it just needs a more powerful computer. Perhaps getting a more powerful ITX board would be a great way to start. The Camera’s are low definition, and need a more powerful board to run well too. The data that was collected by the photodiodes was the only data that truly looks like it was worth anything. The HOBO’s work really well, and we see no reason to phase them out.