ILLINOIS INSTITUTE OF TECHNOLOGY

Scarlet Hawk IV

Final Science Report

AIAA - IIT

Demographics

Name	Gender	Ethnicity	Race	Status	Disability	Team
James Henry	M	N	White	UG	N	All
Alan Grossman	M	N	White	UG	N	Structure
Vaishnavi Sreenivash	F	N	Asian	UG	N	Structure
Gregory Enriquez	M	Y	N/A	UG	N	Structure
Ibon Rementeria	M	Y	White	UG	N	Structure
Gina Kapadia	F	Y	N/A	UG	N	Structure
Noah Griffith	M	N	White	UG	N	Structure
Jaime Anton	M	Y	White	G	N	Structure
Jacob Freeman	M	N	White	UG	N	Software
Ian Gustafson	M	N	White	UG	N	Software
Simon Sai	M	N	Asian	UG	N	Software
Kevin Hardin	M	N	White	UG	N	Hardware
Caterina Lazaro	F	Y	White	G	N	Hardware
Sergio Gil	M	Y	White	UG	N	Hardware
Timothy Bender	M	N	White	UG	N	Hardware
Diego Avendano	M	Y	White	G	N	Hardware

Team Structure

The Illinois Institute of Technology HASP team was broken up into three groups. As seen in the demographic information, we had a structural team, hardware team, and software team. The leaders of the project are as follows:

- James Henry – Project Manager
- Jacob Freeman – Software Team Leader
- Kevin Hardin – Hardware Team Leader
- Alan Grossman – Structural Team Leader

Payload Specifications

Structural

For the 2015-2016 HASP project, the IIT team reused the primary structure from last year. The only real changes made were the creation of a new FRP external shield, and some minor modifications to the metal frame to make it simpler to construct/deconstruct. The following are CAD images of the original structure to outline its design:

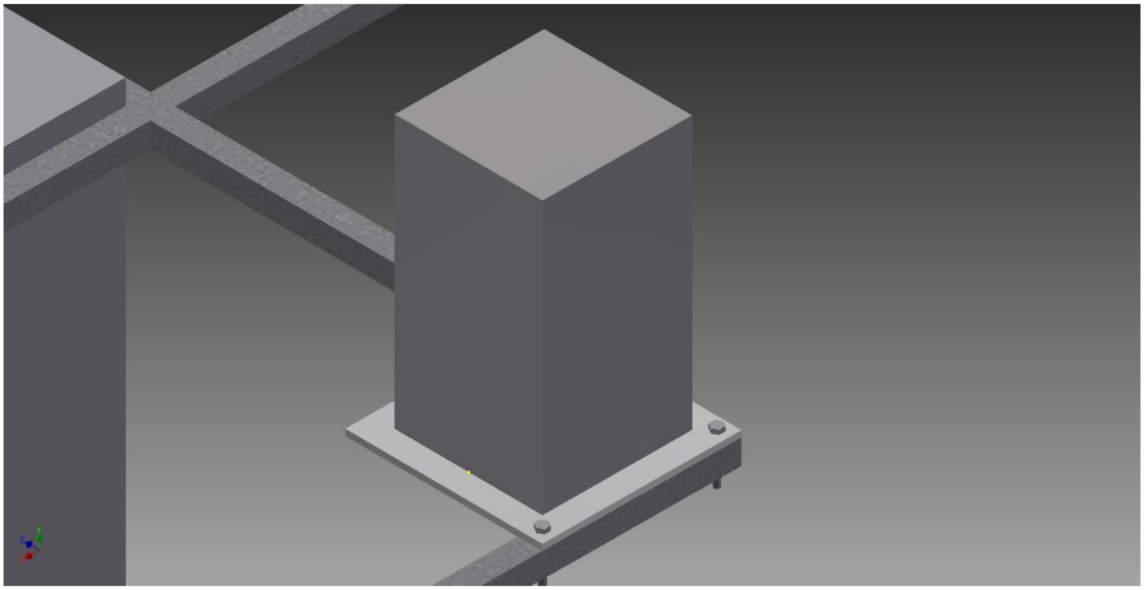


Figure 1: *Similar to last year*

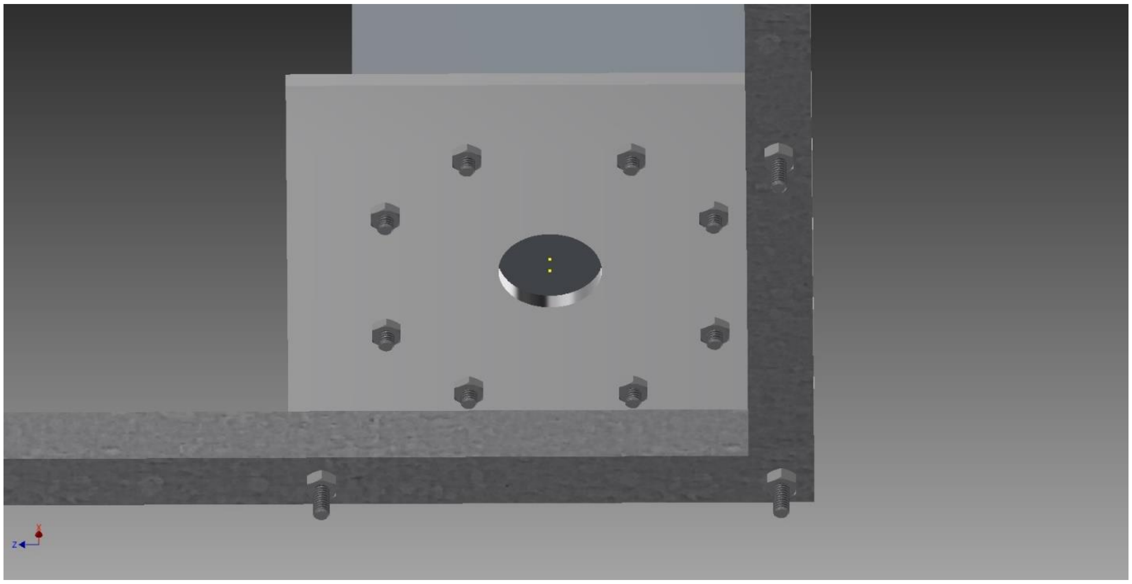


Figure 2: *Baseplate attachment to platform, as well as payload attachment to plate*

(*) The hole in the baseplate has a 4cm diameter

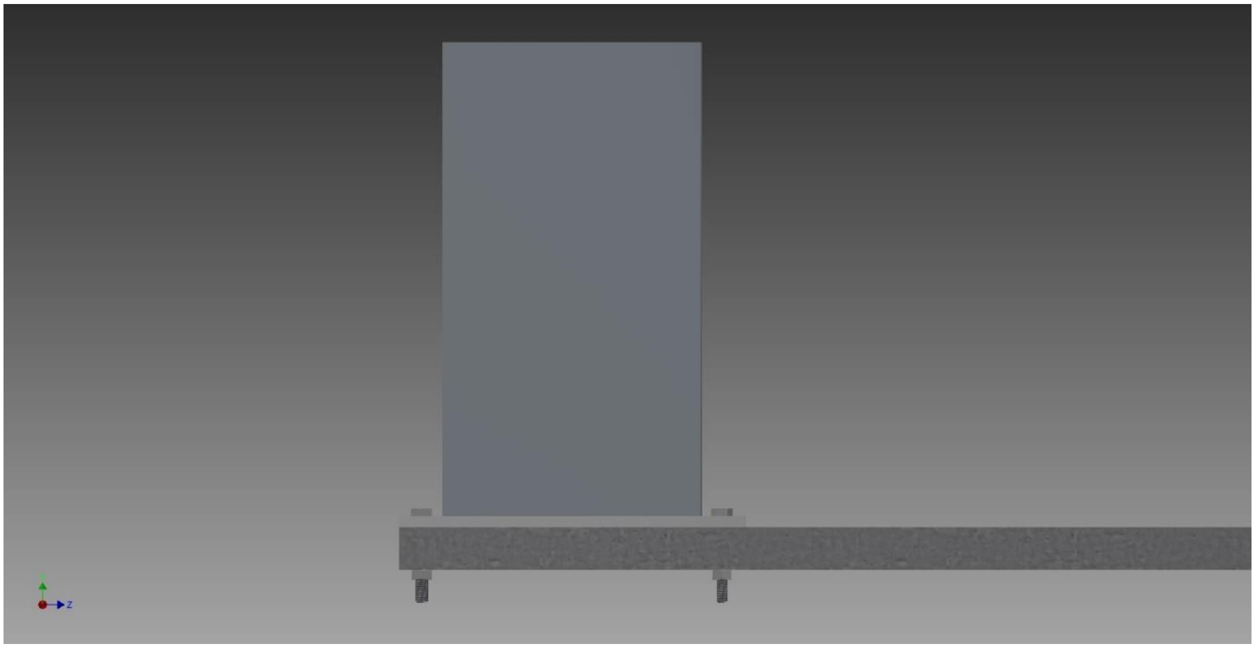


Figure 3: *Attachment as seen from the side*

The next images will show the dimensions of the structure and its different parts

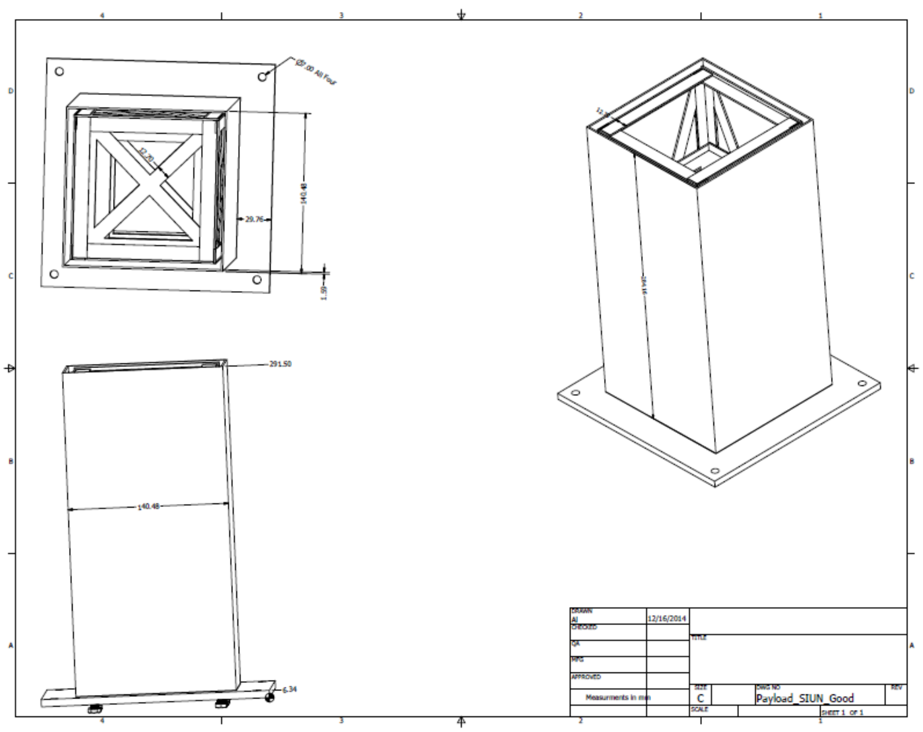


Figure 5: *Small payload dimensions*

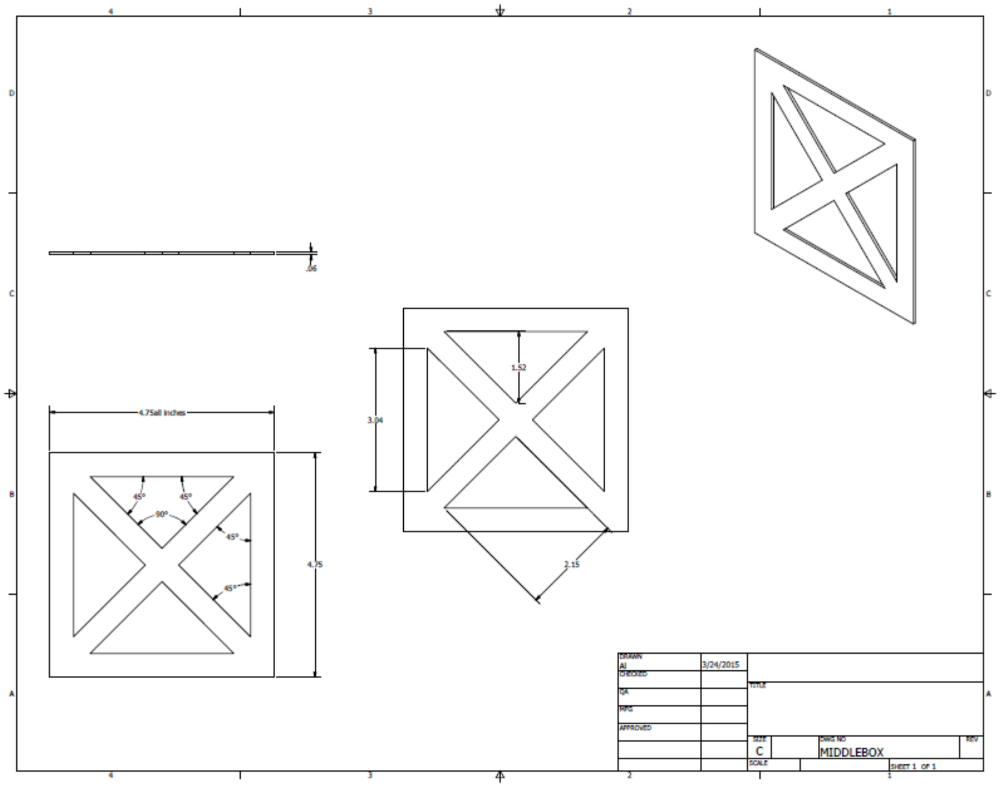


Figure 4: *Detail of the top and bottom face*

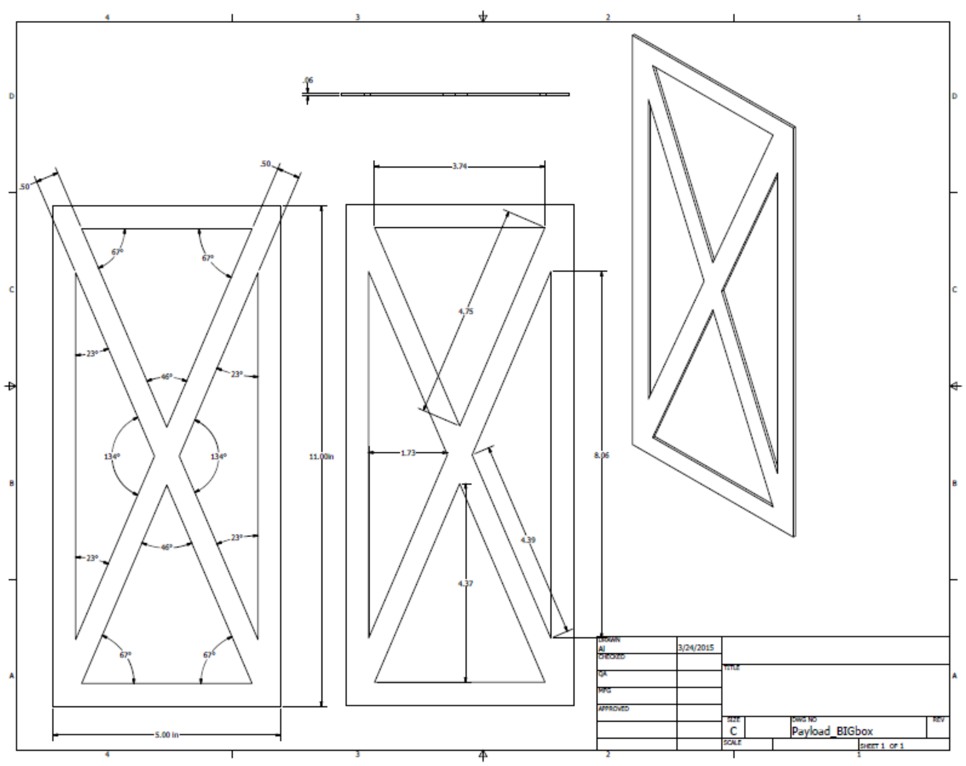


Figure 5: *Detail of one lateral face*

As is clearly visible from the drawings, the structure utilized an X frame design to increase strength while minimizing weight. The design was originally done by Alan Grossman with some assistance by James Henry for the 2015 launch. The payload itself maintained form very well, and because of this we chose to reuse the metal frame and it once again performed extremely well.

Software and Hardware

The 2015 IIT payload ended up straying from the original goal of performing communications tests from the suborbital flight to performing atmospheric observations, while focusing on observing the radiation levels as a function of altitude. The final list of sensors and relevant power information on board are as follows:

Component	Quantity	Voltage	Current (Max)	Power
HIH6130	x1	5.0 V	1.0 mA	0.005 W
MS5803-14BA	x1	3.3 V	1.4 mA	0.005 W
Geiger Tube	x1	5.0 V	30 mA	0.150 W
Gyro/Acc	x1	3.3 V	3.9 mA	0.015 W
Hack HD Camera	x1	5.0 V	1.0 mA	0.005 W
Arduino	x1	12.0 V	80 mA	1.040 W
Total		**N/A**	**536.3 mA**	**5.185 W**

As was just mentioned, the Geiger tube was the focus of this experiment, but we also collected information regarding pressure (MS5803), and temperature (HIH6130). The pressure value was fairly useful in our data collection as a method of measuring the altitude for better comparison with the Geiger tube data. It was known prior to the experiment that the Geiger tube ran at very high voltages, so with this in mind, while in Texas, we performed an additional test on the Geiger tube alone, to see if the electricity arced. Unfortunately, it did, so we had to take the payload back to Chicago, pot the Geiger tube, then send the payload down to New Mexico.

The software provided a great number of challenges up until the final testing day in Palestine. The entire payload is operated by an Arduino Due, and the programming for the advanced sensors used on board made the job very complicated. The serial downlink record function was formatted as follows:

<Head><$S_{Tmp/hum}$><S_{Gyro}><$S_{Pressure}$><S_{Geiger}><S_{GPS}><S_{Camera}><Time><Footer>

(18 Bytes = 144 bits)

Byte #	Data	Function
1	Header	Flag for the beginning of the packet
2	$S_{Tmp/Hum}$	Values of the temp/hum sensor
4	$S_{Pressure}$	Values of the pressure sensors
6	S_{Gyro}	Values from gyroscope
8	S_{Camera}	Camera ON/ OFF flag
10	S_{Geiger}	Value from Geiger Counter
13	Time	Time in milliseconds
17	Footer	Flag for end of packet

Although the data came in smoothly during the mission, it took a lot of work to get the payload to that point. After on site modifications were made to the boards, the software had to be almost completely rewritten. There were a great number of problems with the premade Arduino libraries for these components, and Jacob Freeman personally rewrote each of them such that they could function as a system.

Problems Encountered

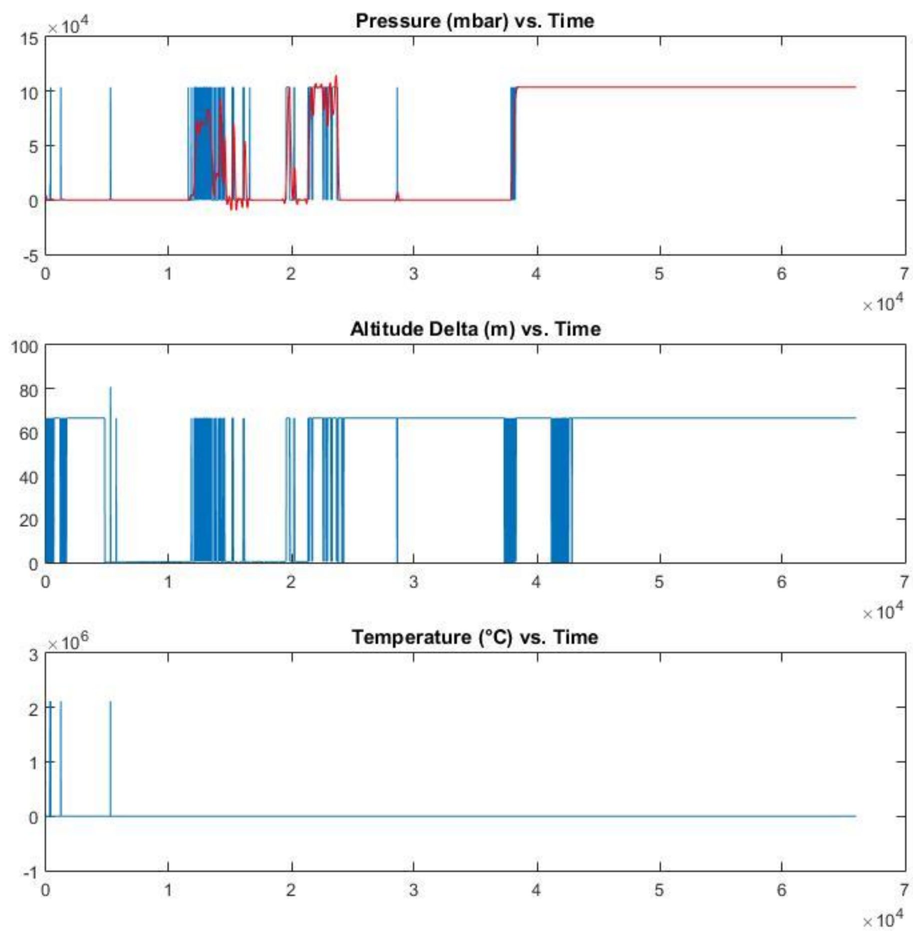
Each of the teams encountered a variety of problems throughout the creation and implementation of this payload. The problems that the structural team first encountered were with supporting the boards within the payload. The original plan was to make a rail system, however, the PCB ended up being slightly larger than the metal frame could accommodate with rails. Once we arrived in Texas and discovered the situation, we made a trip to the store and purchased some plastic parts which we then cut apart and epoxied into the shape necessary to hold the boards. In addition, once the boards were all put together and placed inside the payload, we came to the realization that the Geiger tube was facing directly into the metal frame. We then took the payload apart, brought that piece over to the machine shop and had a hole drilled into it to allow the Geiger tube full access.

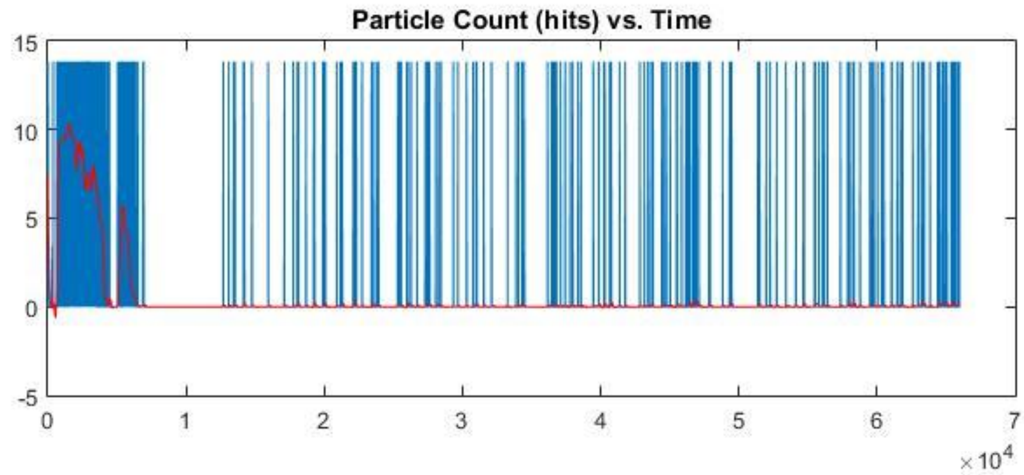
The software team's problems were already briefly described in the previous section regarding the rewriting of the libraries such that the data was acquired from the sensors to the Arduino. In addition to this, the software team, and the whole group, had a massive amount of difficulty in getting the serial output properly programmed. We were lucky enough that one of the other participants from another school who had worked previously as an electrical engineer, was willing to take the time to help us. He provided a great deal of knowledge and support, and we would certainly not have been successful without his help.

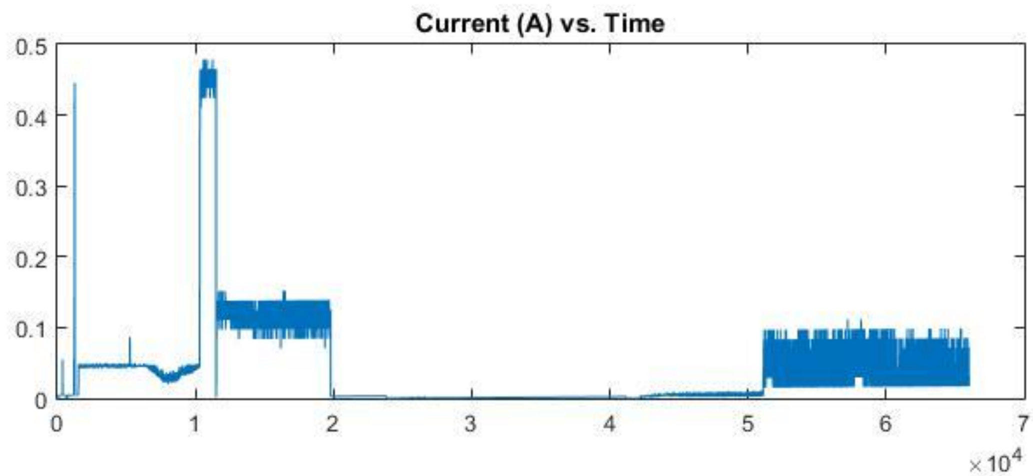
The hardware team's problems were very much intertwined with the problems of the software team, but before the software team could even have problems, the hardware team had to put together the boards that would be programmed. The boards initially were made to only take 30 volt DC and send that through a surface mounted circuit that would separate it into the different voltages needed. In addition, one board had our transmitter circuit on it, which we were no longer using due to the excessive difficulty involved. These circuits both had several problems, and we had to basically recreate the circuits externally, by hand. Luckily, we had the foresight to bring multiple voltage regulator pieces with us, and once we made the power handling circuit, rerouting these to the sensors and relevant components was no problem at all!

Performance and Data

The payload went up very early in the morning, and we were up and watching the data stream. As our data came in we actively graphed it and watched to make sure there weren't any issues. As the mission went on, there were multiple power cycles that we requested to attempt to restore functionality to a couple of sensors, and that, for the most part was successful. The raw graphed data can be seen below:







Unfortunately, as is clear from the data, some of our sensors had a number of problems during the launch. The pressure sensor evidently was damaged and caused faulty readings on altitude, temperature, and pressure, because they were all connected to the same sensor. However, our mission was revolving around the Geiger counter, and that worked beautifully. There are multiple moments of high density with the pings for the particle read. Our tube was programmed to send a single binary ping if it had picked up any alpha, beta, or gamma particles since the last read. While at float, you can see multiple locations where there are spaced out areas and more dense areas. It can be assumed that these have to do with the orientation of the payload with regards to the sun. The data where the large gaps are are likely due to the payload facing away from the sun entirely. While on the ground and during ascent, it looks as though the payload experienced a great deal of radiation. I believe if the payload was programmed to ignore alpha particles, we would have more comprehensive data regarding the radiation related conditions in the upper atmosphere.

Conclusion

It’s obvious from the number of issues we ran into throughout the process that we had a lot to learn. First and foremost, it’s important to understand the communications failure. Overall, the communications mission was too ambitious from the start, because the people running this year’s mission all had no experience in communications systems. We designed a system that made sense on paper, but in reality, our methods of surface mounting were not sufficient for the components, and it appears as though the process should really be more iterative than we attempted.

In addition, we learned a large amount about the reliability of different sensors, and the methods that have to be used to calibrate them and keep them calibrated. The sensors were an absolute hassle, because we would get one to work, then once another one was in, the others would stop working again. With this in mind, we now understand far better that all systems have to be designed to allow for every individual piece and must be designed as just that: a system.

Overall, the experience was very positive for everyone involved, and the experience has already garnered a great deal of resumé attention for members from potential employers. All of the members had a great time being a part of such an exciting project, and would happily do it again, were someone to take over as the project manager.