SASTA OLIPHANT
SCIENCE AWARDS

Prize Winner

Programming, Apps & Robotics

Year 5-6

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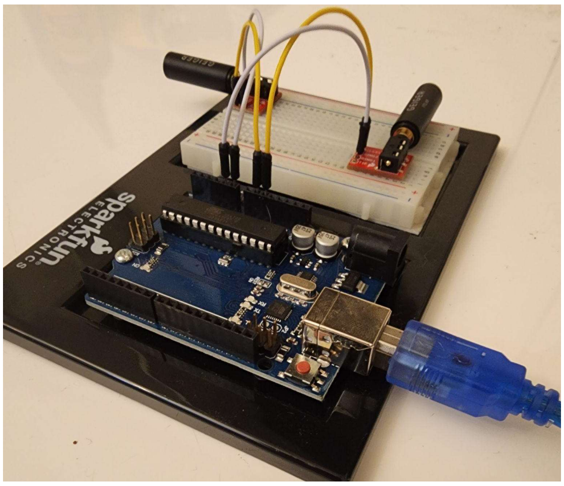
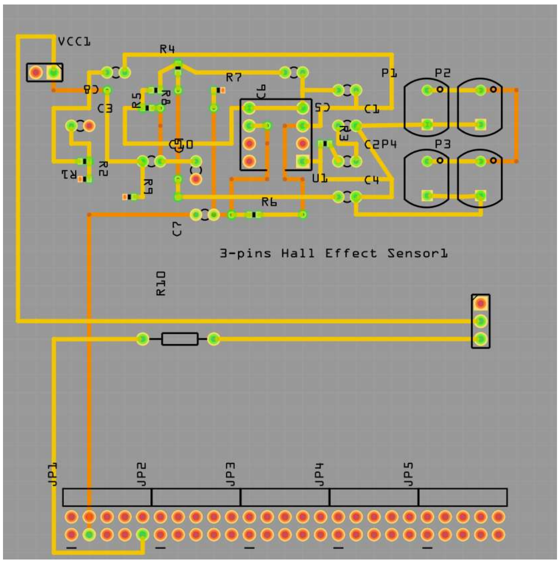
St John's Grammar School - Junior School

Sensors For Suborbital Space





Introduction:

I have wanted to launch a payload to space for a long time so after hard efforts now I am. At the end of last year, I decided that I wanted to make my own satellite simulation that would be space capable, at the time it was not planned to go to space because it didn't seem possible. Later, I was at home, and I had a call from my Dad.

He had found a way, an opportunity, for me to send my project to space with Robinson Aerospace Systems and The Exploration Company. This opportunity is special to me because all my life I have been heavily inspired by space exploration.

I'm launching my payload on a SpaceX rocket! I call it VXS Space.

A big problem in space is radiation. Radiation is deadly and life changing (in a negative way). I want to test the radiation levels in suborbital space and covers for radiation sensors to investigate which covers will best block out radiation.

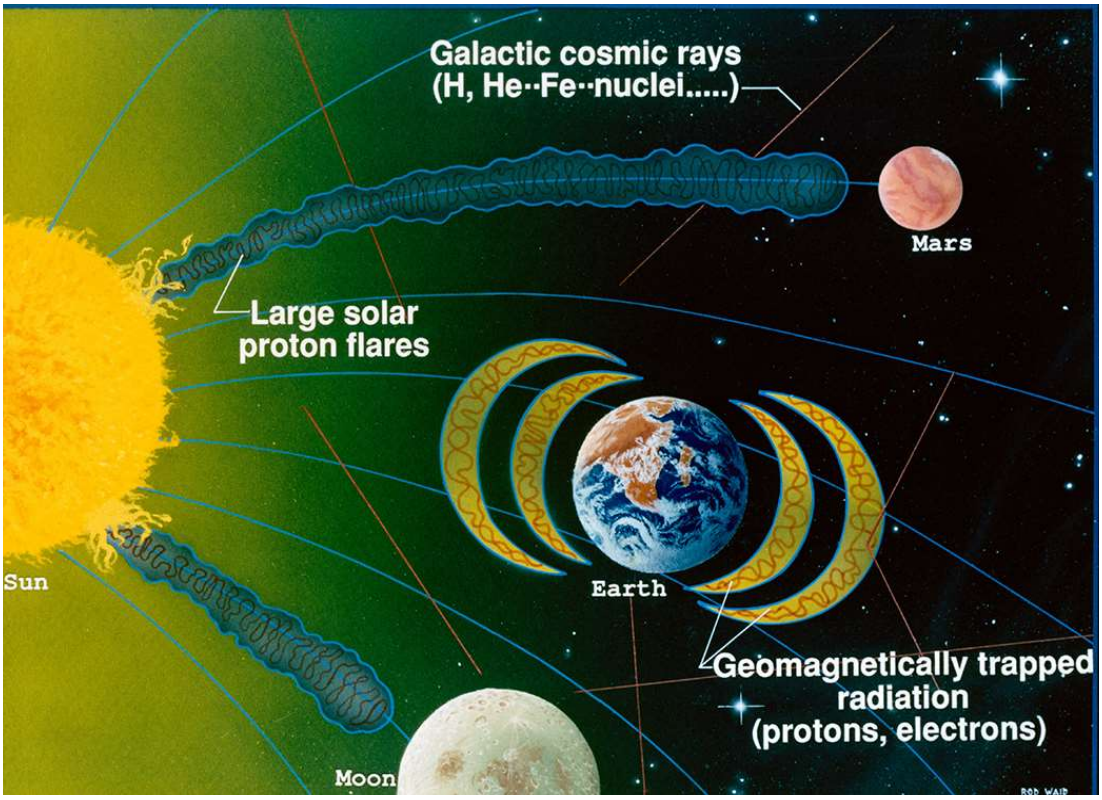
My science experiment will measure radiation in space and test what materials are best to block radiation. This will help the future of space exploration. Another thing is to measure the electromagnetic field (EMF). Hopefully this project will inspire a lot of children to get interested in space exploration. On the way of the journey, I also have a goal of learning PCB and Schematic design.

The time I met Richard Tonkin and Owen Mace (OSCAR-5 Australis)

Understanding Space Radiation:

Before we figure out how to block radiation, we must know the basics. Simply, radiation is a type of energy that comes from a source and travels near the speed of light in space. It has an electric-like field and magnetic field with it as well. Radiation also has wave-like properties however another phrase for this is electromagnetic waves. It can include things like UV rays, X rays and Gamma rays, however radiation comes in many different types across the electromagnetic spectrum including visible light rays. UV, X and Gamma rays have a lot of energy. When they interact with atoms, they can remove electrons and cause the atom to become ionised. As mentioned earlier, radiation is a big threat in space to the astronauts and spacecraft electronics. The reason it is so important to measure is because by knowing the threat you can reduce the threat. The way I want to test radiation is by trying different materials on the radiation sensors (Geiger sensors) that can be used to block radiation – maybe one day it can help with astronaut suits, spacecraft and lunar bases.

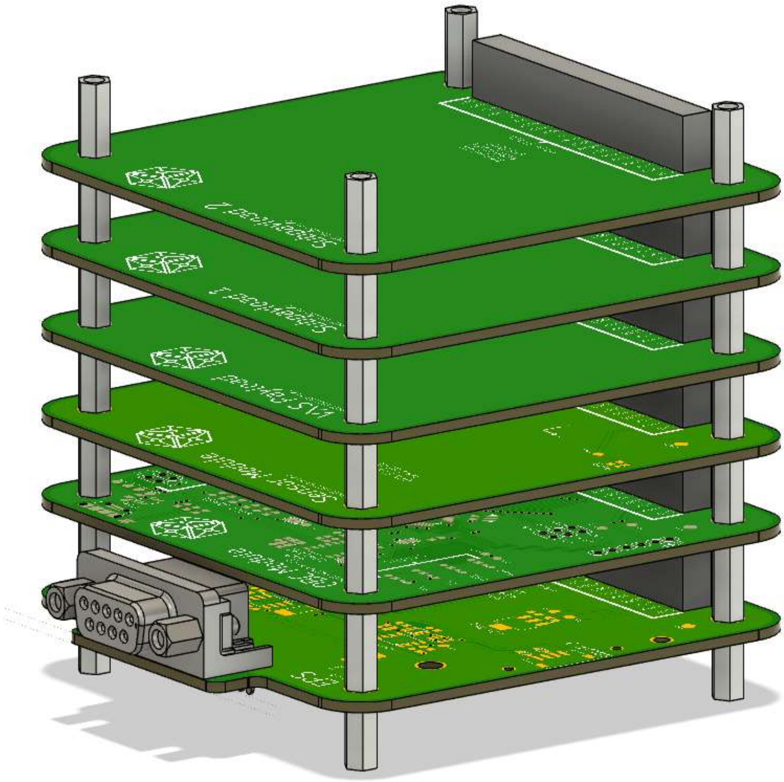
If an astronaut is exposed to too much radiation they could develop cancer, or even develop cataracts or go deaf, however, there are some effects of radiation still unknown to humans to this day.



A scientific Diagram of Solar. GCR rays coming from the sun.

Introduction to Payload Design:

What is a payload? It is an object that will fit into a spacecraft. I will only be talking about spacecraft payloads. It is important to know that there is a weight limit, and the heavier the payload is the more money it will cost. There is also a limited amount of space. The capsule my payload will be in will have other types of payloads - pressurised and unpressurised.



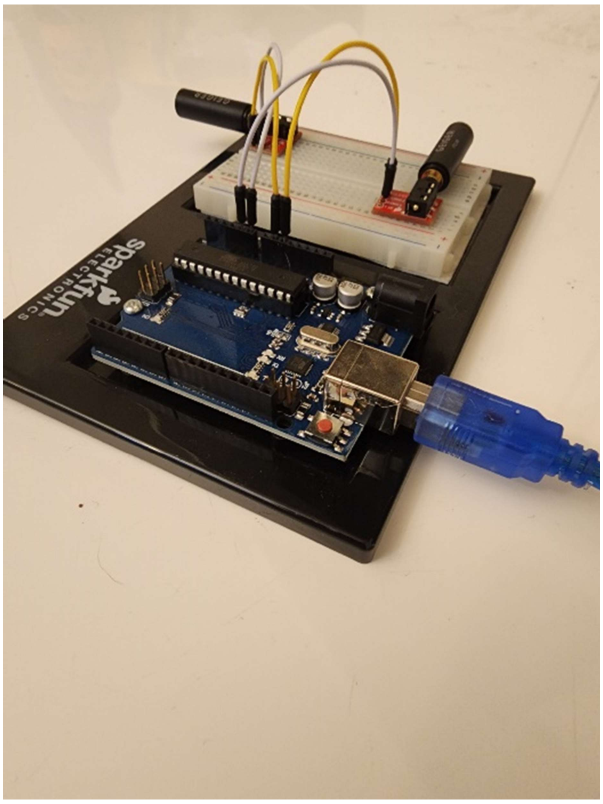
Platform for my experiment by Robinson Aerospace Systems

Pressurised means that it will not be open to the vacuum of space and unpressurised means it will. My experiment will be unpressurised.

There are also many requirements to make my project space compatible, for example, I can’t use lead-free solder because the tin can ‘whisker’ in the vacuum and cause a short circuit. My payload also needs to go through the vacuum testing, temperature testing and even vibration testing. My current plans are to do this at Mt Stromlo in the ACT.

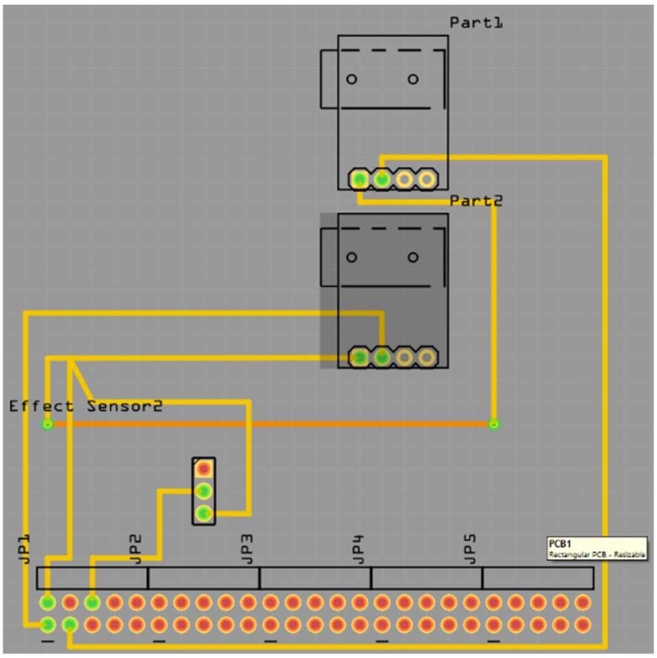
Prototyping and Testing:

Before creating a PCB, I had to make a prototype. For my prototype I used 2 Geiger's, 2 TRRS Jacks, an Arduino, Breadboard and some cables. I used the Geiger sensors created by FT Lab. Once learning how use the Geiger's with Arduino I managed to get them working with a small bit of code. For the final plan I would have had 3 sensor's and 2 of them would be testing covers. These Geiger's were made to measure Gamma Radiation, which is the most dangerous in space.



I created a PCB for this design until I found out that these sensors may have lead-free soldering on the inside. Lead-Free cannot be used because it may short circuit causing a spark. I concluded that it would be best to create my own radiation sensor.

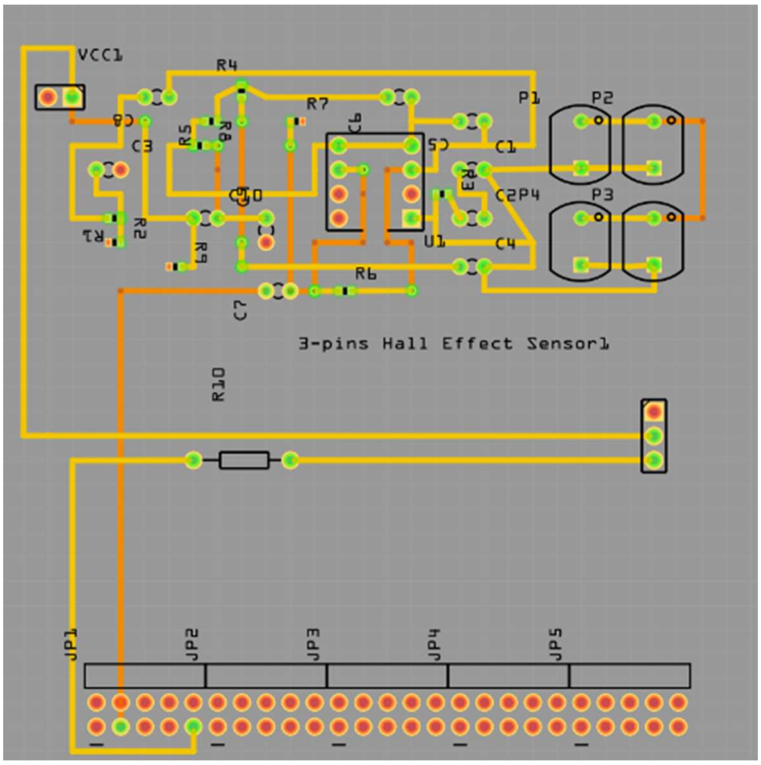
Close up circuit board of prototype.



Prototype PCB.

Designing a PCB Radiation Sensor:

My radiation sensor uses photodiodes to measure the radiation. A photodiode is an electronic device that can be used to measure many different things. What makes a photodiode different from all other diodes is that a photodiode is light sensitive, meaning it measures things using light. A photodiode allows light or infrared, ultraviolet radiation, X Rays and Gamma Rays. This is why I will use photodiodes for my sensor. When it comes to soldering my sensor, it must not be soldered with Lead Free soldering otherwise it can cause a short-circuit. I used Fritzing for designing the PCB however, when starting this project, I had no experience on Fritzing, so I had to learn online. I made many alternate PCBs however settled on 2. 1 for the TRRS Geiger and one for the custom-made sensor.



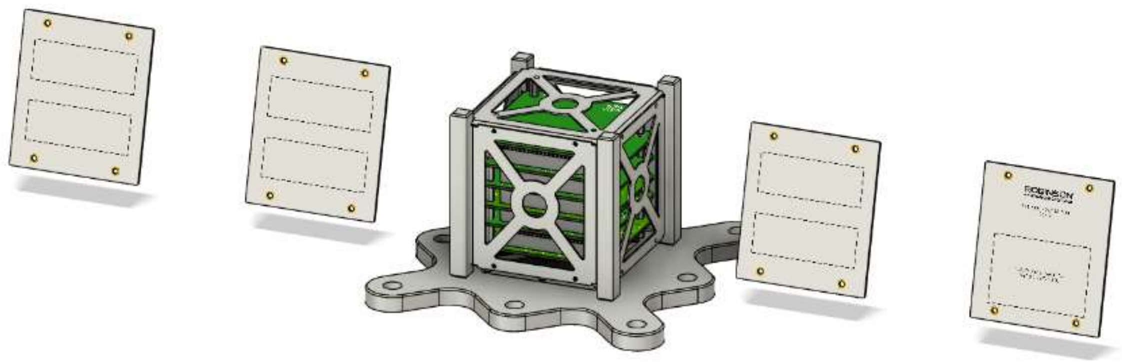
PCB Design with Photodiodes

Payload Platform

Me building RAS Cube

On March the 27th I went to the RAS Cube Launch Event at the Australian Space Discovery Centre. Edward Robinson, the founder of Robinson Aerospace Systems ran it personally to give out his first set of RAS Cubes. A RAS Cube is a set/kit from Robinson Aerospace Systems that will teach you how to make a replica satellite. I was the first person to get this kit at the event and have been in the process of building it since then. It is a very fun project with pre-built parts. Once and you finish the PCB stack you can move onto the case, and then there will be more things to do after that until you have a model satellite that once setup properly, can be used for data that comes on the app that connects to the RAS Cube.

Payload Design and Construction:



Payload Display Post-Flight

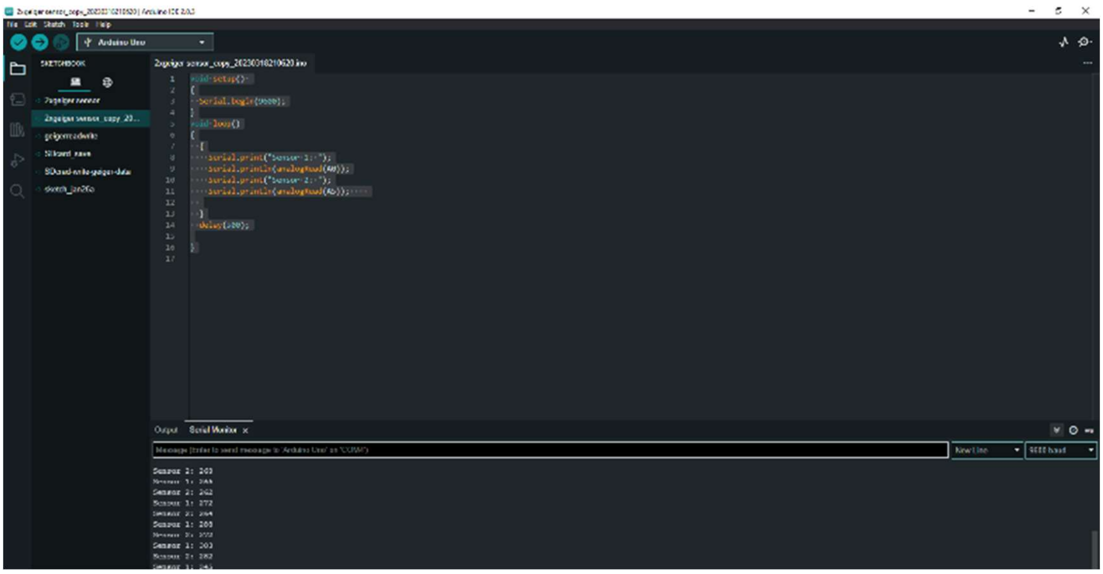
Of course, there are many requirements to the payload design. Firstly, each PCB must exactly be 75x75mm. There is a 1kg weight limit including all the computing provided by Robinson Aerospace Systems. I am only allowed to use 1 PCB for my experiments. The final requirement is that it obviously must be space compatible. Many of the other PCBs will be from Robinson Aerospace Systems which will allow my payload to get power, and all PCBs will have the same pin holes as the Robinson Aerospace Systems (RAS) pinholes. My PCB will also include:

- 10 Resistors
- 10 Capacitors
- 4 Photodiodes
- 1 3-pin hall effect sensor
- 1 Power Plug In
- 1 OP27G
- TRRS
- FT Lab

This list is for only one Geiger however there will be multiple Geiger's/sensors on the PCB board however still only 1 hall effect sensor.

Developing the Application:

For this PCB I used C++ for programming because I used Arduino for my prototypes and C++ is the programming language used for Arduino. I used the app Fritzing for creating PCBs and Schematics. Even though I used Fritzing I did attempt to use Ki Cad however by then I had already learnt fritzing. JLC PCB is an app that can be used to order and create PCBs designed and saved as Gerber files. I used the analogue section on an Arduino and a PCB to receive data from the Geiger's which are used to measure radiation and test covers. Hall effect sensor were used for measuring the EMF of the atmosphere. For testing I used the Serial Monitor built into the Arduino app. There have been no confirmed materials on what I am going to use but as of right now I am planning to use aluminium and lead wrap.



Arduino Software

Launch Opportunity and Collaboration:

Meeting Edward Robinson and a Hannah from The Exploration Company

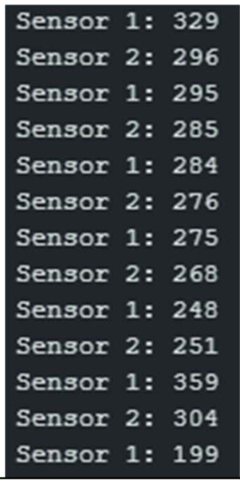
The official project has been called VXS and has made collaborations and opportunities along the way. The first one is called Robinson Aerospace Systems. Their part in the project is the engineering services and complex flight testing, especially the vibration and temperature. The second one is The Exploration Company. They provide the NYX capsule and all the payload information storage. This will launch on a SpaceX Falcon 9. The final one is the Space Elevator. They are an educational group in France partnering to provide space flight experiments for schools across six continents however they are separate from VXS. I'm hoping that this project will inspire kids around the world.

Presenting my project at the Australian Space Discovery Centre for the RAS Cube Launch

VXS comes with many opportunities but also a lot of challenges. The biggest opportunity is being able to launch a payload into space. I have also enjoyed learning about space engineering processes. It is an amazing opportunity to meet and network with scientists and other people within the space industry. Most of the challenges have been hard but fun at the same time such as learning new complex concepts and working with remote teams. Another one has been electronic challenges such as learning PCB design which I enjoyed.

Flight and Data Collection:

The Falcon 9 my payload will go in will enter sub orbit meaning it will only orbit the Earth up to three times. The Falcon 9 will launch no time before October 2024 and my payload will go on the NYX capsule from The Exploration Company same as all the other payloads. My data will be stored on the EEPROM so after recovery I can read the files. The data will be imported into Excel so that I can use the Excel data analysis graph so I can manually create a graph to visually see the results. After the data analysis I will hopefully know which of the tested covers block radiation the best or if they work at all. There is a chance that no covers will work, but that is part of the science. I will also test how strong the EMF of the atmosphere is.


```
Sensor 1: 329
Sensor 2: 296
Sensor 1: 295
Sensor 2: 285
Sensor 1: 284
Sensor 2: 276
Sensor 1: 275
Sensor 2: 268
Sensor 1: 248
Sensor 2: 251
Sensor 1: 359
Sensor 2: 304
Sensor 1: 199
```

Data from Sensors

Innovation and Contribution:

The payload also has many contributions to science and engineering. This can contain PCB and Schematic Design, however; this is more of a normal engineering process. The major contribution to science is in testing low Earth orbit radiation and how well different materials will shield from it.

Me at the ISU night with Dr Parsons

Future Developments and Applications:

There is a lot of future potential for my payloads. The first one is that it would be good to have a radio antenna which was in the original plan but was not available in the NYX capsule. The reason this would be helpful is because we could have real time communications, so we get the data during the flight. In the future the payload can have many more sensors which means different covers and materials to test. EMF in orbit is not considered a threat as it is a non-ionising radiation however some scientists believe that EMF can cause cancer through other parts of your body so I could add EMF covers. The reason this would be useful is because we could take this data into consideration when creating astronaut suits and spacecraft to reduce the danger. For the best safety I believe that it would be important to be able to tell how much a certain dose would affect a human. As my payloads evolve, I would also like to create an app for data to share across the world, and one day maybe I can contribute to actual development of products to space.

RAS Payload Design

Conclusion:

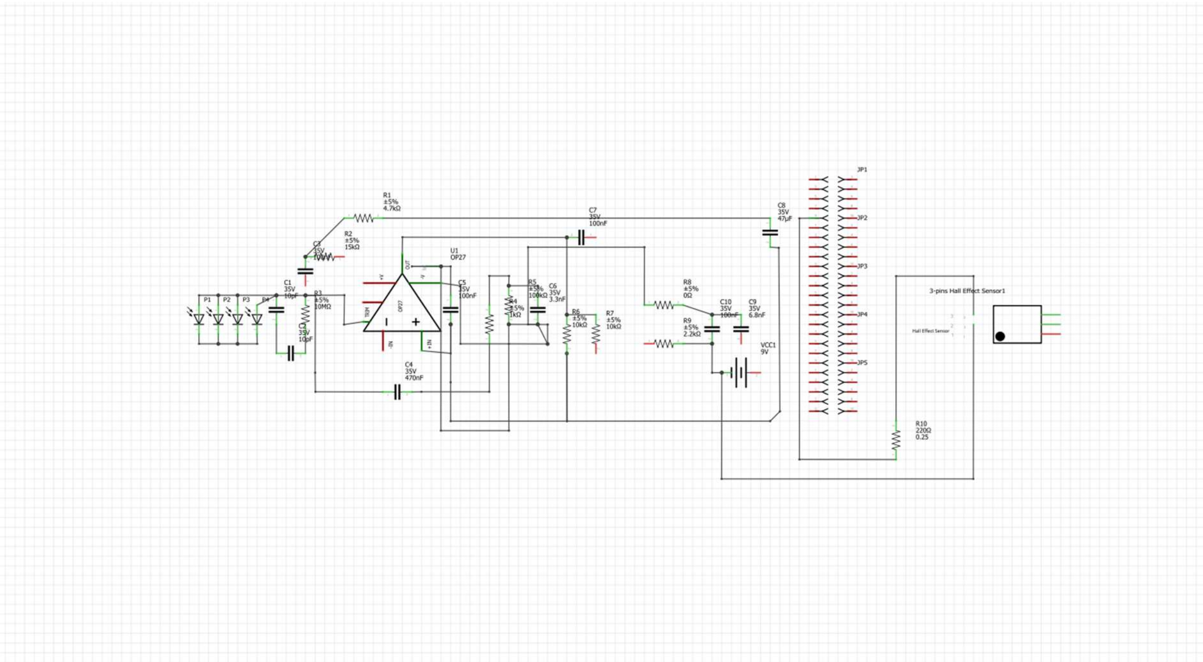
Throughout this project there have been many achievements. I have created my own custom Geiger, PCB, and schematic. I will measure the hall effect and test which cover blocks the most radiation. The main achievement is that I will be launching something to space. During this project I have achieved some of my main goals with many more to come, however, I feel that overall, I worked the best in PCB design. What I need to improve on is time management. With that sorted out I will have much better-quality projects.

Hopefully this will inspire other kids to get involved with space. That will be a great achievement.

Stay tuned for launch next year!

Appendix:

Detailed Schematics



Code

```
void setup()
{
  Serial.begin(9600);
}
void loop()
{
  {
    Serial.print("Sensor 1: ");
    Serial.println(analogRead(A0));
    Serial.print("Sensor 2: ");
    Serial.println(analogRead(A5));
  }
  delay(500);
}
```

Test Data and Result

Sensor 1: 337

Sensor 2: 319

Sensor 1: 301

Sensor 2: 295

Sensor 1: 265

Sensor 2: 268

Sensor 1: 228

Sensor 2: 240

Sensor 1: 213

Sensor 2: 227

Sensor 1: 222

Sensor 2: 225

Sensor 1: 239

Sensor 2: 236

Sensor 1: 272

Sensor 2: 254

Sensor 1: 303

Sensor 2: 277

Sensor 1: 339

Sensor 2: 302