NASA CONNECTICUT SPACE GRANT CONSORTIUM

High School Rocketry Payload Design

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Introduction

The Discovery Museum and Planetarium is a hands-on science museum in Bridgeport, CT, whose mission is "to engage, excite, and educate young learners through experiences and programs that inspire wonder and ignite creativity as the foundation for a lifetime love of science, technology, engineering, and mathematics (STEM) learning."

Fig. 1. "El Grande" during takeoff at the CATO Rocket Club launch site. Photo: Elliott Severn

I had the opportunity to work on one of these programs, the high school rocket club. The rocket club debuted during this past 2017-2018 school year. The students first competed in the Team America Rocket Challenge, and then began work on building a high power model rocket kit, the Black Brant II, from Apogee Rockets. I assisted these students in getting this rocket flight ready towards the end of the school year. On June 16th, 2018, "El Grande" completed a successful flight and recovery, deploying its dual-parachute system in order to return the 10-pound, 6-foot long rocket safely to the ground.

After this launch, I was tasked with the assignment to develop a system that will enhance the educational opportunities "El Grande" can provide to students beyond its maiden flight.

Background

I worked with David Mestre, the Director of the Henry B. duPont III Planetarium at the Discovery Museum, in order to envision the future of the "El Grande" model sounding rocket as an educational tool. We took inspiration from the NASA "Rock On" workshop, a week long workshop funded by the Colorado and Virginia Space Grant Consortiums, in which several university student teams learn to build a sounding rocket payload and launch their work on a real sounding rocket up to about 73 miles. Our program would have groups of high school students build their own custom electronic payloads that collect data of their choosing and communicate with a main flight computer. This main computer would be in charge of sending all the data back down to the launch site via radio communication, as well as writing a copy of the data to an SD card.

Methods

The design work of this project largely fall into two main categories: the mechanical structure and the electronics. I designed both aspects of the payload concurrently, since they inherently depend on each other.

First, I laid out a general data flow diagram, showing how data from a student's payload moves from sensor to ground station. Due to simplicity and availability of documentation, we decided that students should use the Arduino Nano as their module computer. It's a small, commercially available microcontroller board that has the same capabilities of the popular Arduino Uno, but with a smaller footprint. These can easily communicate with a wide variety of sensor breakout boards that can be purchased from vendors like Adafruit or SparkFun. These sensor boards can be selected by students to suit their experimental interest, and often come with Arduino libraries and documentation material that make them accessible to students and museum staff with minimal experience. I decided this over designing circuits from scratch largely with the knowledge that this program should be able to be run by museum staff without my specialized knowledge.

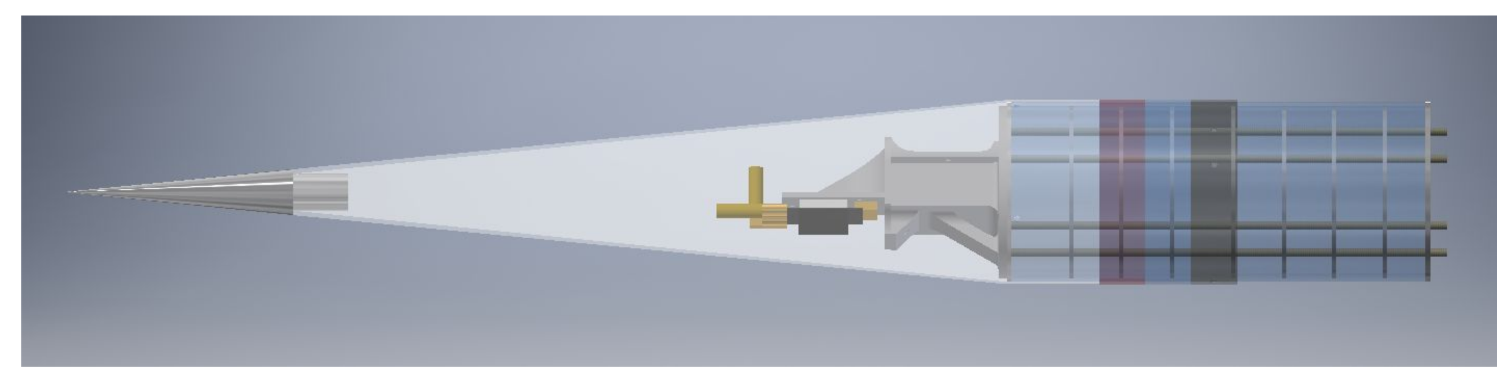

Fig. 2. 3D CAD model showing the final payload assembly, featuring up to six student bays and a radio module in the nose cone. Image: Giselle Koo

Each of these Arduino Nanos then package up all their data into a standardized format and send it to the main flight computer, a Teensy. This Teensy communicated with each student module through a single UART Serial port, along with a custom "chip select" circuit designed by me. The Teensy also wrote to an SD card through SPI and a GPS and Radio modem through two separate UART ports.

I designed a custom PCB that handled all of these connections, along with the necessary power regulation circuits in order to supply the different voltage levels to operate all of these devices from a 2 or 3 cell lipo battery. The schematic and board were created in Autodesk EAGLE, and was ordered from a small-batch PCB fabrication service called OSH Park.

Throughout the electronics design, I had a general idea of the physical structure of the payload: the main flight computer, radio, and battery would be housed in the nose cone of the rocket, and the student modules would slide into a cylindrical "coupler" section immediately below the nose cone. I first sketched my design very generally by hand, and then drew and assembled the various components in Autodesk Inventor.

We decided to purchase several structural parts from the same company that created the original rocket kit, Mad Cow Rocketry, to ensure that our parts would fit with the kit's nose cone and body tube without issue. Additional structural elements, such as a box to hold the battery and mount electronics to, were to be 3D printed, or were basic hardware components available commercially. Ease of fabrication was a priority in this design: it must be relatively easy to replicate with tools commonly available to an institution such as a museum.

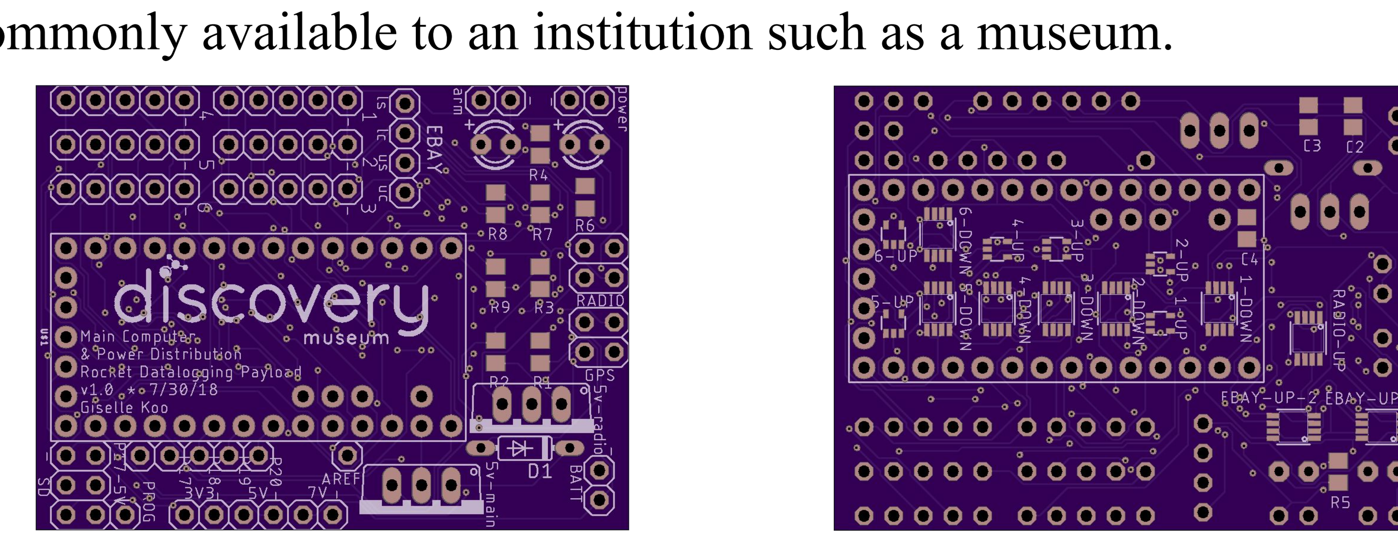

Fig. 3. Proof rendering of the main rocket computer PCB, which includes power regulation and connections to student payloads, GPS, an SD card, slot, and the downlink radio. Image: OSHPark

Results

This internship resulted in the creation of a finished design for a modular experimental payload. The fabrication of all the parts is still in progress, due to unexpected issues with a 3D printer. We hope to do a test launch this September or October, before the rocket club begins for the school year at the museum.

Conclusion

This experience was very valuable to me as an engineering student. My program at Tunxis Community College does not offer college credit for self-directed engineering study, and such experiences are few and far between in the standard classes, so this was a particularly invaluable opportunity to me.

During this internship I was responsible for creating a solution to a practical problem. I gained a lot of experience in iterative designing, applying engineering principles to a real world situation, and in Computer Aided Design, both for physical mechanical structures in Autodesk Inventor, and electronic schematics and PCB design through Autodesk EAGLE. I believe the most effective and lasting learning can be found through such experiences and am grateful for the opportunity provided by the Connecticut Space Grant Consortium.