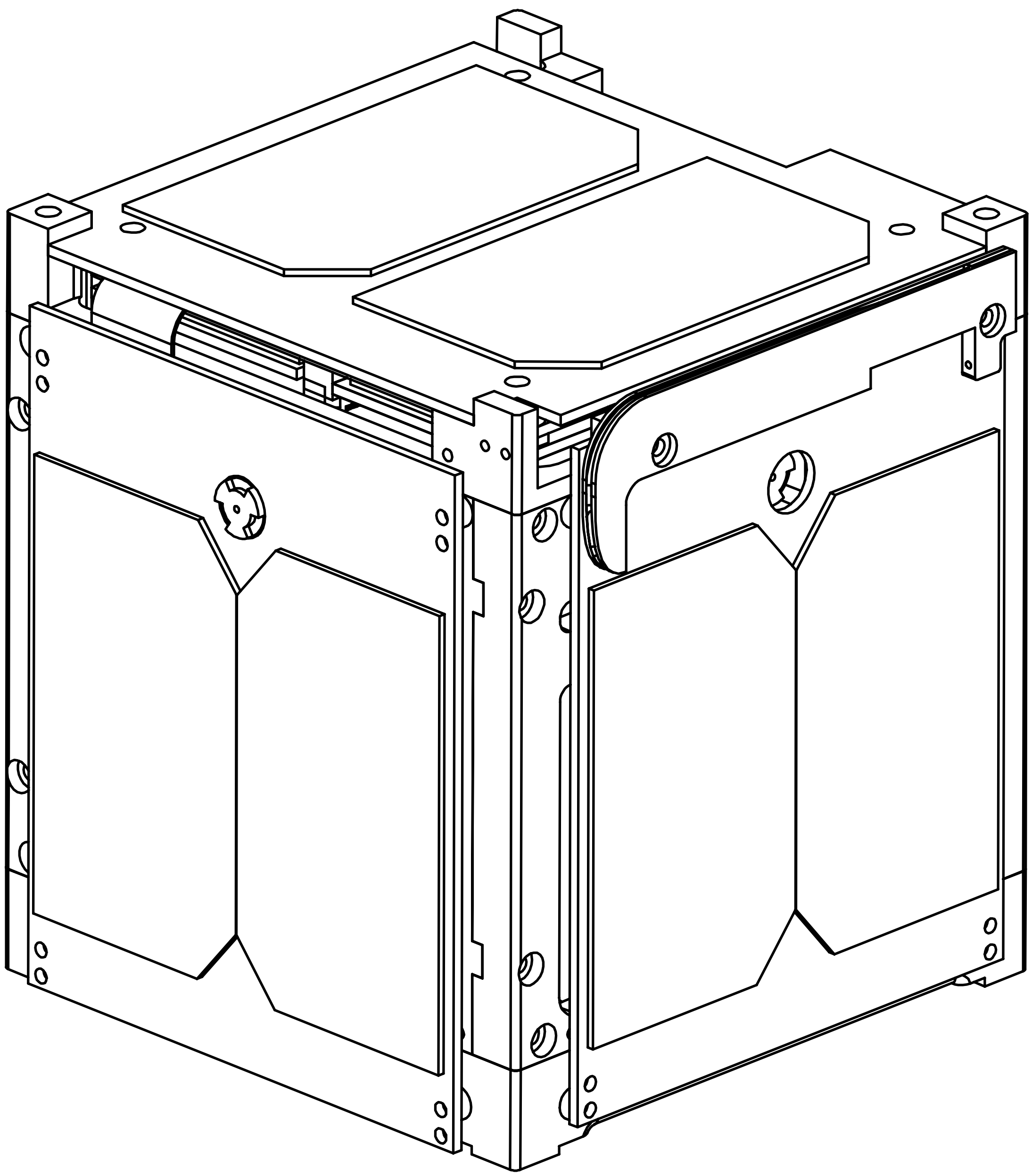
Eric Baumgarten

Engineering Portfolio



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High Altitude Balloon Flight Structure

Goal:

Design a enclosure for a high altitude balloon flight that will validate hardware for the IPEX CubeSat

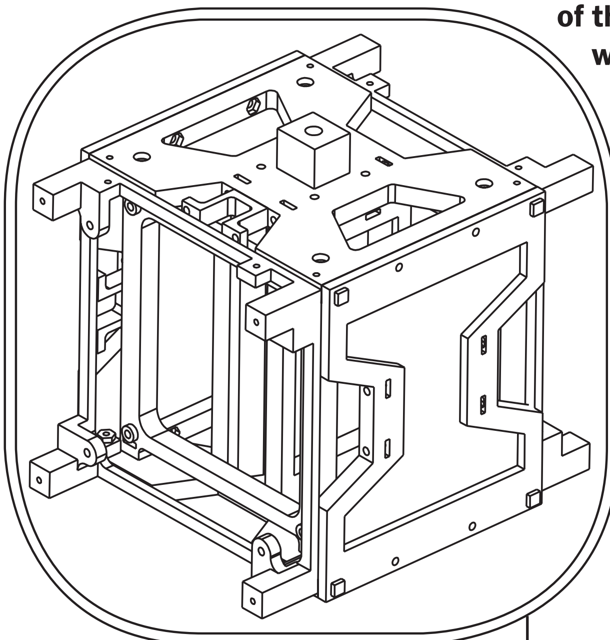
Challenges:

The enclosure was required to withstand the extreme temperature of the earth's upper atmosphere while enclosing avionics of a specific geometry. The enclosure was designed to be manufactured on a Objet Eden 3D printer. The use of 3D printed material required the design to incorporate specific hardware cutouts to assemble the structure.

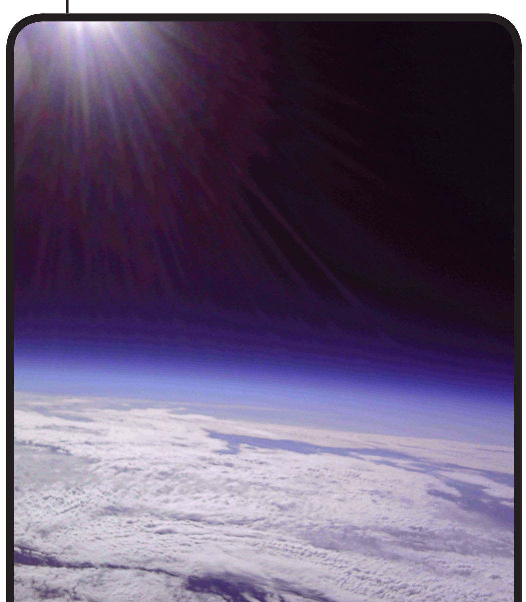
Design:

The balloon flight structure was designed to be incorporated as a payload on a Edge of Space Science (EOSS) flight. This meant that the structure needed to be incorporated onto a flight string with other payloads. The center of mass needed to be as close to the center of area, this lead to the mounting of the batteries to the center support. To deal with the harsh environment in the upper atmosphere a styrofoam protective shell was fabricated to help insulate and protect from moisture build up.

The enclosure required cutouts for the flight string and cameras. The structure was designed for ease of assembly and disassembly that was required for testing reasons. Protective steel plates were incorporated into the design to help protect the avionics upon impact under parachute.



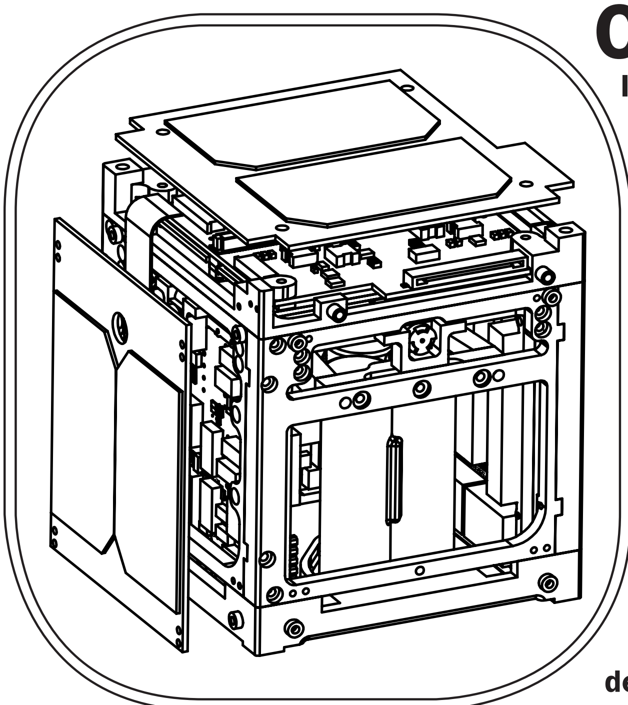
CAD drawing of the balloon structure



Picture taken during the balloon flight

Fully integrated balloon flight structure

IPEX CubeSat Mechanical Lead



CAD Drawing of IPEX

Overview:

IPEX is a 1U cubesat built in collaboration with JPL as a mission to demonstrate operation of autonomous instrument processing. The payload software was created by JPL while the space craft bus design and integration was done by Cal Poly's PolySat.

Responsibility:

As the mechanical lead of the IPEX Cubesat I had a number of responsibilities. I was required to ensure proper placement of all of the spacecraft components.

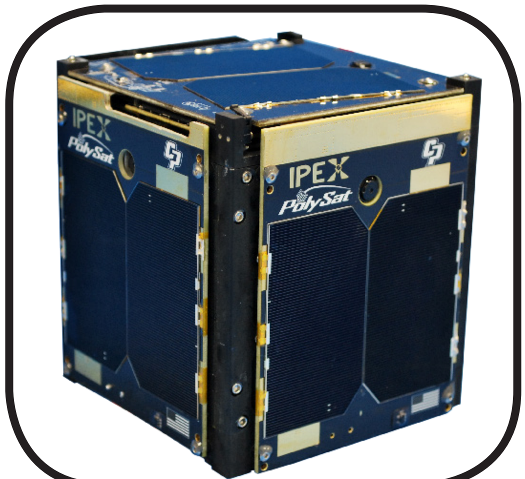
Ensure the proper manufacturing of the structure.

Write detailed assembly plans for flight unit build.

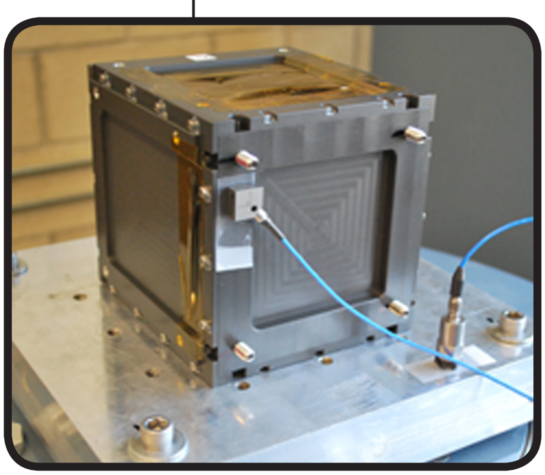
Write detailed procedures for environmental testing of spacecraft. Write detailed documentation on design of spacecraft to ensure to launch providers the safety of primary payload. I also helped perform environmental testing and assembly of spacecraft.

Integration:

I was responsible for creating the assembly procedure of the IPEX cubesat. This task required detailed thought and iteration in order to ensure proper order of assembly. With the inclusion of avionics the assembly of the cubesat becomes a daunting detailed process that requires numerous builds before the flight unit to ensure proper assembly procedures



IPEX Flight unit



IPEX on vibration table

Testing:

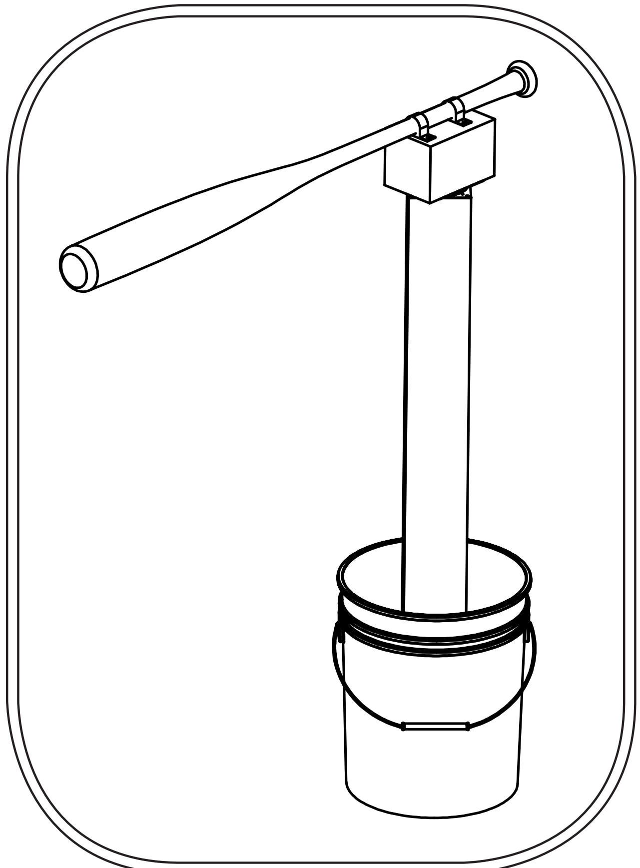
A main part of the project that I was responsible for was the environmental testing of IPEX. CubeSats are required to go through vibrations and thermal vacuum testing. I was in charge of writing test plans and organizing the testing for the engineering and flight models of IPEX. Other tests that I helped on were vacuum testing for antenna deployments and magnetic characterization.

Experimental Analysis of Baseball Bat

Goal:

Measure the response of baseball impact on ash baseball bat. Use the measurements taken to characterize the response of the bat. Use this characterization to help design a baseball bat that is less prone to breaking.

Baseball bat with strain gauges in test stand

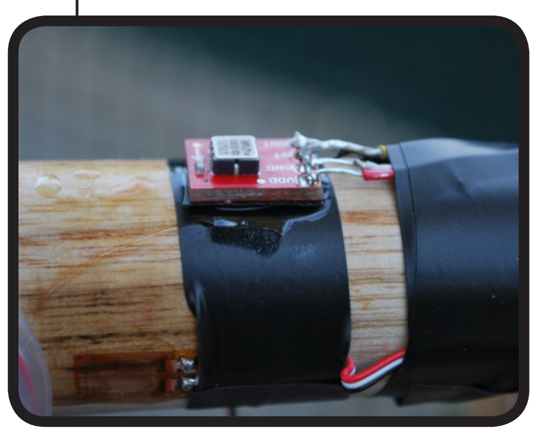


CAD Drawing of test stand

Setup:

In order to properly characterize the response of the bat a set of three strain gauges along length of the bat and one accelerometer were secured to the bat. The output of the strain gauges and accelerometer were recorded using a digital oscilloscope for its high frequency data acquisition. The baseball was impacted at a controlled speed using a pitching machine at four locations along the bat. 5 impacts were performed at each location to ensure valid data. The bat was held using a test stand that can be seen above. The test was also performed as swung by a person. We are able to compare the results of the hand swung bat to the test stand.

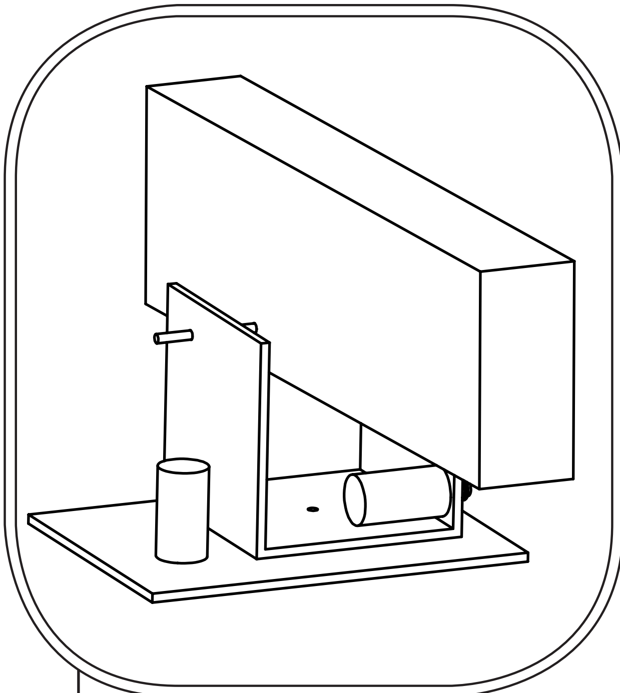
Closeup of strain gauge and accelerometer



Results:

As direct measurements we were able to measure the strain and accelerations produced for impacts along the length of the bat. From these strain and acceleration measurements we were able to obtain the natural frequency of the bat and damping ratio of the test stand compared to hands. The data showed that hands had a much larger damping ratio than the test stand. Results also showed that impacts closer to the hands and at the tip of the bat create much larger strains than impacts in the 'sweet spot' of the bat.

Autonomous Dueling Nerf Blaster



CAD Drawing of initial design

Goal:

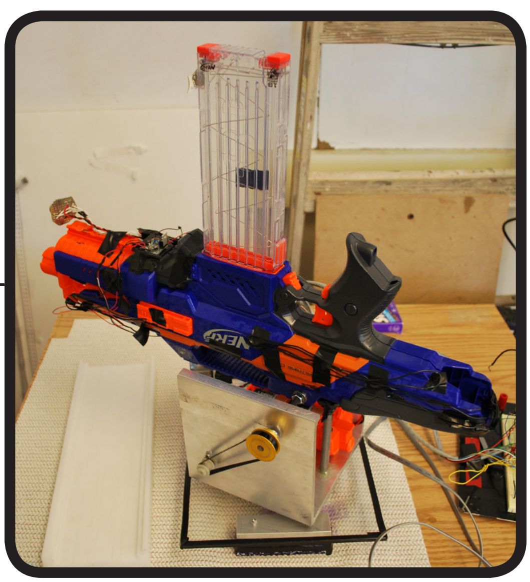
The goal of this project was to design, build and test a mechatronic system that would be able to participate in Nerf blaster 'duels' with other team's projects. The blaster was required to begin in a starting location, turn 180 degrees and find the enemy's light source as a target and fire autonomously.

Design:

A fully automatic Nerf blaster was controlled on both its pan and tilt axis using two brushed DC motors and timing belt pulleys. The motors and other components were controlled using a custom board that used a Atmega 1281 processor and two motor controller chips. The board was programmed using C++ to have two axis control of the blaster. The system would search for the light source using a photo-transistor circuit and would fire upon finding the source using a MOSFET circuit attached to the Nerf firing mechanism.

Results:

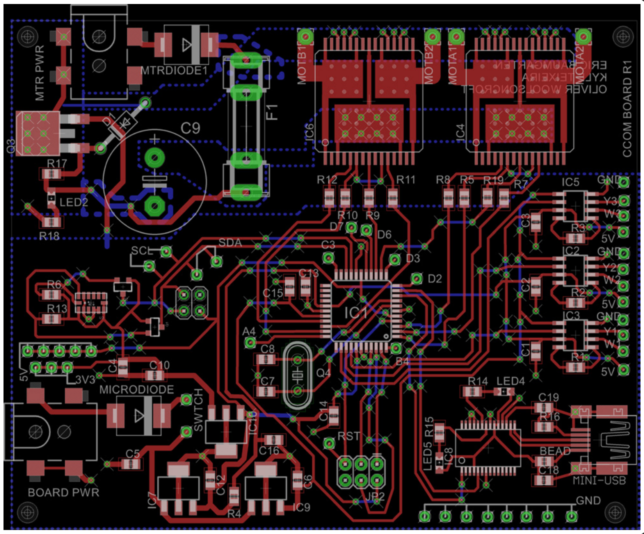
This project was completed in an accelerated time line (3 weeks). This lead to some trade offs in the functionality of the assembly. The total mechanical system was completed which allowed for full 2-axis control of blaster and the ability to fire the assembly. There was not enough time to complete the calibration for the autonomous light source search and fire.



Side view of final assembly

Front view of final assembly

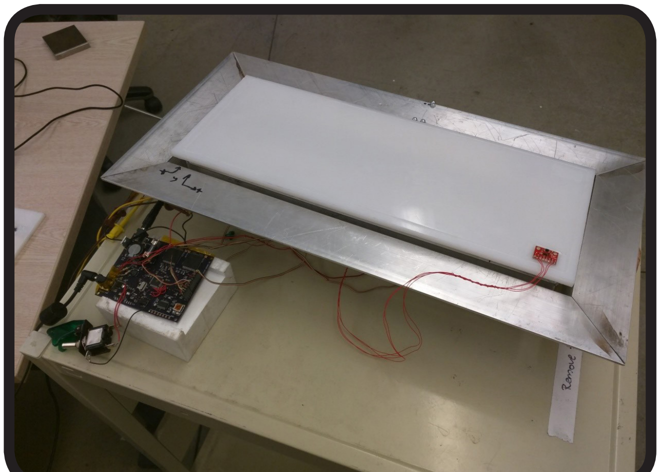
Cubesat Center of Mass Table



PCB Layout

Goal:

The center of mass is an important detail that feeds into both the attitude design and launch characterization of cubesats. The center of mass is typically estimated using CAD software, but that can produce inaccurate results. The purpose of this project was to design a mechatronic system that would automate the center of mass measurement of a 1-3U cubesat. This system would be relatively inexpensive and accurate enough to meet cubesat design specifications.

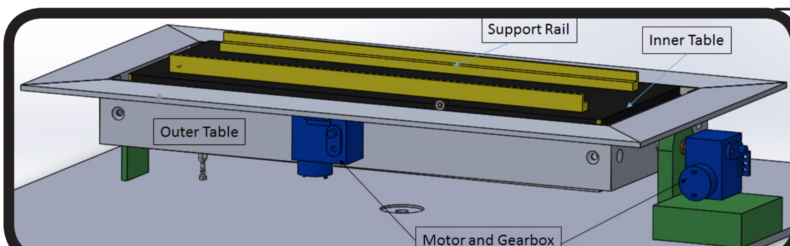


Final table prototype

Design:

The center of mass (COM) table is fully automated for ease of use by the cubesat developer. Three load cells are placed under the inner table. The cells feed into a triangulation algorithm to determine the center of mass of the cubesat which is placed on top of the table. The load cells were chosen to be able to handle a cubesat from 0-4Kg with sufficient resolution. The angle of tilt of the table drives the accuracy of the COM. On the table there are two worm gear boxes that drive the tilt in two axes to automatically level the measuring table. This automation prevents the developer from having to level the table by hand. The angle of tilt is measured using a 2 axis accelerometer. The entire table is controlled by a custom designed PCB that was developed in support of this project. An ATmega 644p microcontroller is the brains that controls two motor driver chips, reads the accelerometer, processes the three load cell's input data and outputs the data to a LCD screen. The microcontroller is running C++ code to facilitate the tasks.

Table CAD design



Results:

The table was developed as part of a 10 week quarter term project. In the span of the quarter the table's mechanical, electrical and software designs were developed from an idea to a prototype stage. The PCB was ordered, soldered and debugged. The structure was machined and assembled. The code was written and debugged. All of this work culminated in a working prototype that was able to measure the weight of a cubesat accurate to 0.02Kg, the COM in 3 axes to 0.7 mm and actuate and measure the tilt to 2°. The project work was continued after the course to polish the design into a usable tool for the cubesat design lab PolySat.