(C.H.A.N) Balloon

Climatic **H**igh-**A**ltitude **N**avigator
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Authors

Zion Franz — *Electrical Engineer*

Jake Dorfman — *Electrical Engineer*

Lily Sigg — *Photonics Engineer*

Hector Parra — *Electrical Engineer*

Sean Rego — *Electrical Engineer*

Advisor
Dr. Chung Yong Chan

Chapter 1: Project Summary

For over half a century, Central Florida has been the center stage of America's space odyssey; from the Saturn rockets to the Shuttle program, to the rise of SpaceX and the fall of Boeing; Floridians have bore witness to it all. Although it is easy to get lost in the glory of multi-billion dollar space endeavors, there are few avenues for amateur space exploration. Despite this, there are plenty of people who are interested in pursuing a job or hobby in this field. This produces an environment rich in potential contributors for expanding the depth of human knowledge in this field. To this end, STEM kits are often an effective educational tool for removing barriers of entry to a field. While there exist many STEM kits in areas such as robotics, there is less competition with High Altitude Ballooning kits.

The primary objective of the Climatic High-Altitude Navigator (C.H.A.N) Balloon project is to create a Balloon Payload System (B.P.S.) that will be affixed to an off-the-shelf balloon. This balloon will record the temperature, air pressure, humidity, and wind speed during its flight up to 100,000 feet. In addition, the B.P.S. will report the balloon's latitude, longitude, altitude, speed, pitch, and bearing. The B.P.S. will also house the Optical Sub-System (O.S.S.) which consists of a spectrometer and front-end detector electronics. The purpose of the sun-spectrometer will be to detect O_2 and H_2O absorption lines in the VIS-IR (sunlight) spectrum. Finally, the B.P.S. will record video during the flight. This will be accomplished with an action camera such as a GoPro.

Success will be determined by demonstrating each of the system's capabilities during a 150-200 foot tethered launch. If successful, the next steps will be to conduct an untethered high altitude launch in which the payload exceeds 100,000 feet. The desired outcome is to stay in communication with the B.P.S. over the duration of its flight, and recover it upon landing. This will demonstrate commercial viability of our project for educators, hobbyists, and researchers alike.

Chapter 2: Project Description

2.1 Project Background and Motivation

The Central Florida area is well known for its aerospace work. NASA, SpaceX, and Blue Origin are just a few of the local companies that continue to push the boundaries of this field. On Campus, IEEE, Knights Experimental Rocketry (KXR), and the Knights Satellite Club (KSC) are dedicated to aeronautics based projects. Our project inspiration came from one student after designing an ion propulsion system. After finishing that project, he received a flash of inspiration to continue looking upward in both his next project and career. He found a surprisingly high demand for local groups willing to pay to have their own products attached to a high altitude payload. This revelation led to the foundation of our group which eventually became the creation of an affordable, user-friendly system equipped with a wide variety of peripherals.

This payload is meant to be attached to any off-the-shelf weather balloon to be carried to a high altitude. When reaching its apex, the balloon pops and deploys a parachute allowing it to safely land for reuse. The payload will need to be cheap enough to be affordable for beginner level enthusiasts, as well as being light enough to satisfy a variety of federal regulations.

2.2 Current Technologies and Previous Projects

2.2.1 Spectral Telescope for Star Classification

This is a past senior design project aimed at analyzing the spectral range of stars outside the Earth's solar system. The project itself is a long-range telescope capable of figuring out the missing wavelengths in the spectral array response of the star. The spectrometer designed and created for this telescope is in the same family of classification as the one the team plans to use for this project: a Czerny Turner. However, for the Balloon Payload System, the classic Czerny design will be in an unfolded form to avoid using mirrors and reflective gratings. The telescope project utilized the traditional folded alignment, involving a reflective holographic grating and two low transmission concave mirrors [1].

2.2.2 High-Altitude Balloon Kit

There are many off the shelf high altitude balloon kits available for purchase. They typically come with a balloon and a small payload. Our project is unique in the fact that we can custom pick our parts. This means we can go to a desired altitude with our desired payload and get specific desired data. For example Eagle Pro's High Altitude Balloon kit does not come with the ability to downlink information and cameras to capture the flight [2]. Another aspect of our project is that we are equipping our payload with GPS, a sensor suite, and a spectrometer.

2.2.3 UCLan Near Space Balloon

A student group from the University of Lancashire (UCLan) launched a payload that was able to reach 100,000 ft [3]. This group project was more focused on capturing cosmic ray data rather than atmospheric data. It is painted black, likely to reduce noise from light from the detectors and the scintillators in them. We will do something similar as we do not want solar interference due in our Optics subsystem.

We are looking to collect atmospheric, not cosmic, data. We also want this simple enough to be operated by anyone. Their payload certainly needed to follow many extra government regulations, which may be intimidating for a first time user. Their system was launched and had no monitoring capabilities for its data, though it had a GPS system that enabled tracking it down.

2.2.4 UAlbany NASA Eclipse project

This project by UAlbany students was coordinated with NASA [4]. Eclipses are a fairly rare phenomenon and not much is known about how the atmosphere reacts during them. UAlbany collected temperature, pressure, humidity, wind speed and direction during its flight. The payload was launched in New Mexico.

This behavior is what we want to encourage for many local areas. Our goal is less about a particular height and more about affordability, and ease of use. Not having to deal with things like federal approval go a long way to encouraging more people into High Altitude Ballooning.

2.3 Goals and Objectives

2.3.1 Overall Goals

- Successful launch of a payload suspended by a weather balloon, that can measure and record:
  - Temperature
  - Air Pressure
  - Relative humidity
  - Wind speed
  - Velocity (linear & angular)
  - Latitude & longitude
  - Altitude
  - Oxygen gas presence
- Transmit select data such as location & altitude from the payload to the receiver station.
- Present the data collected from the payload's onboard storage in a clear manner.
- Present the live data received from the payload by the base station in a clear manner.

2.3.2 Payload Objectives

- Successfully connect and poll each sensor in a set interval indefinitely.
- Store data in a local unit.
- Transmit data using a radio frequency method to the customer with a base station in range according to the specification sheet.

2.3.3 Optics Subsystems Objectives

- Create an optics system that can collect an incident amount of solar energy.
- Diffract the light into multiple wavelengths.
- Qualitatively determine the presence of O_2 molecules in the atmosphere.
- Optoelectronically interface the light signal into electrical data.

2.3.4 Receiver Station Objectives

- Design a system that allows a customer with a portable electronic device to collect data from the weather balloon.
- Utilize an available GUI able to graphically represent the data collected by the payload.

2.3.5 Stretch Goals

- Successfully reach 100,000 feet.
- Recover balloon from an untethered launch.
- Design a mobile app for Android and IOS.

The primary goal of this project is the successful operation of a Balloon Payload system (B.P.S) during an tethered balloon flight. The project will encompass designing the electrical and optical systems in addition fabricating a container for them.. The design will be compatible with most commercially available weather balloons. The B.P.S. will consist of an onboard sensor suite and an Optical subsystem for gas detection.

The sensor suite includes peripherals for measuring temperature, air pressure, humidity, wind speed, as well as balloon location, altitude, direction, and velocity. The two major subsystems are the Telemetry and Atmospheric subsystems. The shared objective between the subsystems is for our payload to poll each sensor at constant intervals. The primary objective for the Atmospheric subsystem is to provide accurate measurements under the unique circumstances of a high altitude setting. The primary objective of the Telemetry subsystem is to provide an accurate location of the B.P.S during flight.

The optics objectives involve utilizing a white LED as the light source and keeping the entire system dark and contained. Any outside light will result in background noise, making the signal difficult to distinguish. Next, the goal is to diffract it into multiple wavelengths to isolate the absorbance wavelength of O_2 and a wavelength amongst green to provide a high power reference. Finally, the system will detect those two specific wavelengths with two separate photodiodes assigned to those wavelengths.

Another objective is to view the data in real time on the ground. The RF subsystem will transmit data to the base station for display on an LCD screen. The design must be portable and energy efficient enough to work with modern portable devices. A Graphical User Interface (GUI) will also be implemented to process and present the data visually.

After meeting our primary goals, we will move on to our stretch goal. The final test will be hosting an untethered launch that reaches 100,000 feet.

2.3.6 Hardware

Atmospheric Subsystem
The core of our project involves reading atmospheric data at different altitudes. We will employ sensors to get the four basic atmospheric conditions of temperature, air pressure, humidity (RH), and wind speed. The measured data will be stored on a local storage device then transmitted in time intervals to a ground station for a real time display of data. Additionally, we will attach a camera to the payload for a top down view of the landscape. However, to keep the design cheap and simple, the camera will not be sending its video feed. This data will be stored on a separate local storage device for view after collection.

The sensors will face a variety of environmental conditions. They will need to be able to operate within fluctuating temperatures as hot as 30°C to temperatures as cold as -40°C. Additionally, they are likely to experience a large amount of moisture and rain from the clouds and must be protected from the physical forces due to higher winds.

Telemetry Subsystem
The telemetry subsystem records the position, altitude, direction and velocity of the payload while in the air. It includes a GPS, altimeter, and IMU. While it is subjected to the same conditions as the atmospheric sensors, the telemetry subsystem is crucial for retrieval of the balloon. A failed recovery means loss of data since it will all be stored locally on the payload. Additionally, the payload consists of many metal, plastic, and semiconductor parts, which pose an environmental risk in the event of not being able to recover the payload.

Payload Design
The electronics and optics experiment will be housed inside a 3D printed and insulated box we are calling the Balloon Payload System (B.P.S.). This housing must be able to reliably house and protect all of the optical components, antennas, parachute and other systems while being lifted up through the atmosphere by the balloon. From liftoff to landing the payload will be cleverly designed to face and handle a variety of environmental concerns. Although we are not being graded on the mechanical design, this aspect must be able to deliver otherwise it will compromise the entire project. Some of the concerns we are designing around are heavy moisture in the air, low temperatures, and shock of landing. We go more into depth on this topic in our constraints section in Chapter 4.

Radio Frequency (RF) Subsystem

Retrieval of the B.P.S. plays a major role in our design. The RF subsystem requires an antenna and transmitter on the balloon to send information to the base station. The base station utilizes a matching RF module and antenna to receive data packets from the payload to be displayed on an LCD screen.

The communication method is chosen based on the balance of bit rate vs range. Bluetooth, a common method, can send large amounts of data, but only operates at short ranges. Our payload sends telemetry and atmospheric data, which is a small data stream. Therefore, we will choose a long-range method to maximize our retrieval chances.

Optics

The optics subsystem consists of a spectrometer composed of two lenses, a pinhole, and a transmission grating. The light enters through the pinhole and travels along the optical path, where the light is diffracted into the individual wavelengths and focused on the detector. Since a white LED is the source of light in this project, the range of potential wavelengths that can be produced is nearly limitless. Refer to *Figure 2.1.* To take budget and general feasibility into account, the team decided to fashion a simple detector on our own. This component will be just two photodiodes: one at a peak transmission within the visible green region, and one at an absorbance valley in the NIR region.

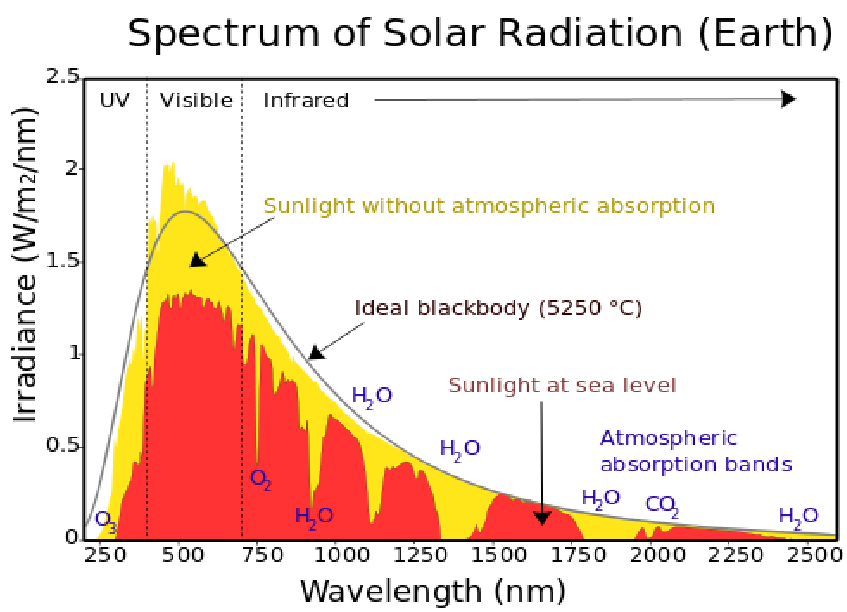


Figure 2.1: *Solar Spectrum. Source: Nick84 [CC BY-SA 3.0] , via Wikimedia Commons*

The white LED will guarantee a consistently adequate amount of power and provides the same blackbody transmission curve as the sun, shown above in the figure. The sun spectrum produced from this setup will have drops in transmissivity, indicating the presence of common atmospheric gasses such as O_2, H_2O, or CO_2 as shown in the solar spectrum graph. Since the detector portion will be limited to only two photodiodes, this means only two distinct wavelengths will be detected. One will be the controlled reference (green) and one will be the absorbance marker for a given molecule. Since O_2 has a sharp drop and is close to the visible spectrum, a silicon-based electronic component can be used. This will be the only gas detected in this project. The further into the infrared means more money invested in the photodiode.

To limit contamination of the system and reduce background signal (light) noise, the spectrometer will be fully enclosed and darkened. To detect oxygen gas, two tubes will be connected to the outside of the enclosure with a clear “cuvette” box connecting them in the middle. This box will be placed between the focusing lens and the two photodiodes. This setup will provide insight on the change in oxygen presence at the different altitudes of the balloon’s position, whether the information be used for weather data prediction or environmental changes over time. The goal and objective for this particular project is to qualitatively provide data, not quantitatively. The spectrometer and detector setup will merely detect the presence of molecules, not the concentration, density, or numerical count.

The general layout of the spectrometer is an unfolded Czerny Turner, starting with an entrance slit, followed by a collimating lens to collect the beam and pass it through a diffraction grating then a focusing lens to guide the separated wavelengths onto the two photodiodes, resulting in two signals. The detector in this system will be a green photodiode to be used as a reference signal (preventing false positives) and a NIR photodiode that operates at the absorbance wavelength of oxygen gas. The resolution will be admittedly low due to time, budget, and physical space constraints on the payload, but the mere presence of the gas – or lack thereof – should be resolvable.

Power

A power system is the key to electrical system operation. It must remain active for as long as the telemetry is needed. An operational time of 3 hours is sufficient for a launch, landing, and retrieval. The power system must take an unregulated, DC battery voltage and deliver stable power to its peripherals. The battery will begin at a relatively high voltage and be stepped down via voltage regulators to a series of power buses. There will be a separate bus for each unique voltage necessary to power each peripheral.

Electronics Hardware Diagram

Refer to *Figure 2.2* for the Balloon Payload System Electronics Hardware Diagram. This illustration shows which member of the team is responsible for each sub system. In addition, it shows how all the components are connected to each other, whether it be wired communication, wireless communication, or power bus.

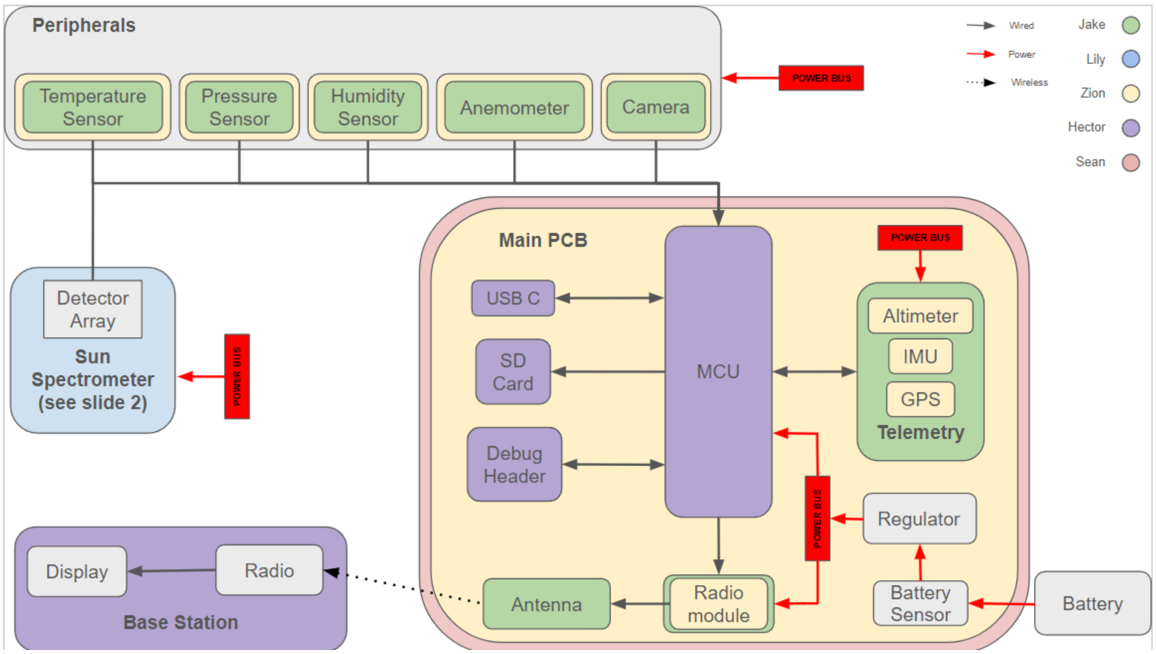


***Figure 2.2:** Hardware Diagram*

Optics Hardware Diagram
Refer to *Figure 2.3* for the Optics Hardware Diagram. It details how the light travels from the slit, through the collimating lens, the diffraction grating and the focusing lens, to the detector array. No dimensions are included in the diagram, as they will likely change multiple times during construction and calibration.

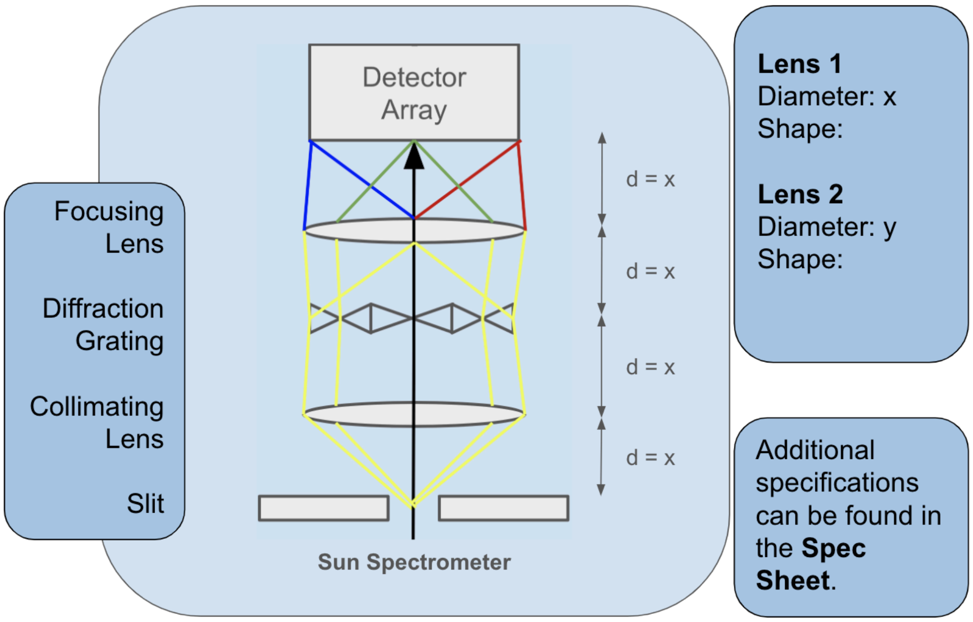


Figure 2.3: *Optics Hardware Diagram*

2.3.7 Software

Payload Software
The main objective of the B.P.S is to receive and collect atmospheric data to observe local weather conditions. The software should be responsible for communicating with each sensor to collect and store the data for use during and after landing.

The process begins with the collection of data from a sensor. It should then be stored locally in separate CSV files for use at the base station. Next, part of the data should be transmitted to the base station via the RF subsystem to show the real conditions and location of the payload. This process must be performed for each sensor fast enough to take reading at constant intervals. 3-4 readings per minute will be adequate to give an accurate representation of the real time measured conditions.

Base Station Software
The B.P.S. is designed to be located and retrieved after launch. The base station software has two functions. The first function is to receive real time updates from the balloon. The software will do this by interfacing with a ground RF module and antenna. This function ensures proper tracking and retrieval of the B.P.S.

The second function is the implementation of a Graphical User Interface (GUI). It will use the CSV files to generate a separate graph for each sensor. The CSV files may also be transferred to any personal device for external processing.

Software Diagram
Refer to *Figure 2.4* for the overall Software Diagram. It includes the work distribution of each member, a general logic tree, and the general flow of data from the sensors to the storage device and base station. The software diagram provides a guideline to the team as we integrate all the subsystems into one uniform product.

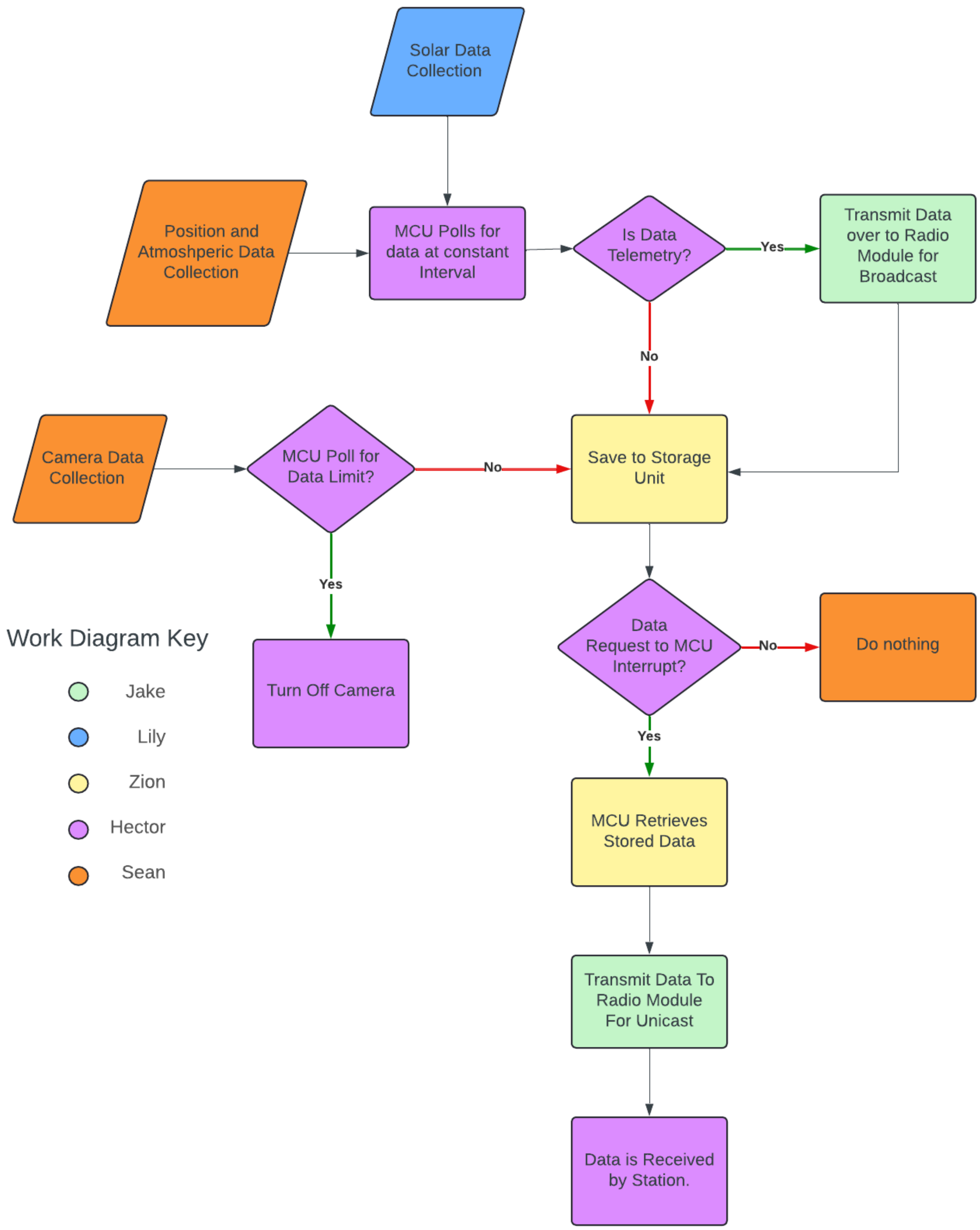


Figure 2.4: Overall Software Diagram

2.4 Specification Sheet

In order to meet our goals and objectives, we must ensure that each part we select is capable of attaining those goals. To do this, we implemented a system-wide specification sheet. Refer to *Table 2.1* for the project specifications.

Table 2.1: *Specifications*
By Authors

Total System Specs	
Operating Altitude	100 - 200 ft.
Battery Lifetime	> 3 hr.
Operating Temperature	-50 - 30 ℃
Total Power Consumption	< 10 W
Mechanical	
Balloon Type	Latex - 800g
Payload Weight	< 4 lb
Payload Dimensions (b x w x h)	12 in x 12 in x 12 in
Parachute Diameter	1.5 m
Flight Train Wire Total Length	> 30 ft.
Rapid Deflation Device (RDD) Type	Hot Wire
O_2 Spectrometer	
Collimating Lens	
Lens Shape	Plano-Convex
Focal Length	12 mm
Diameter	25 mm
Focusing Lens	
Lens Shape	Cylindrical Plano-Concave
Focal Length	15 mm
Diameter	25 mm
Diffraction Grating	

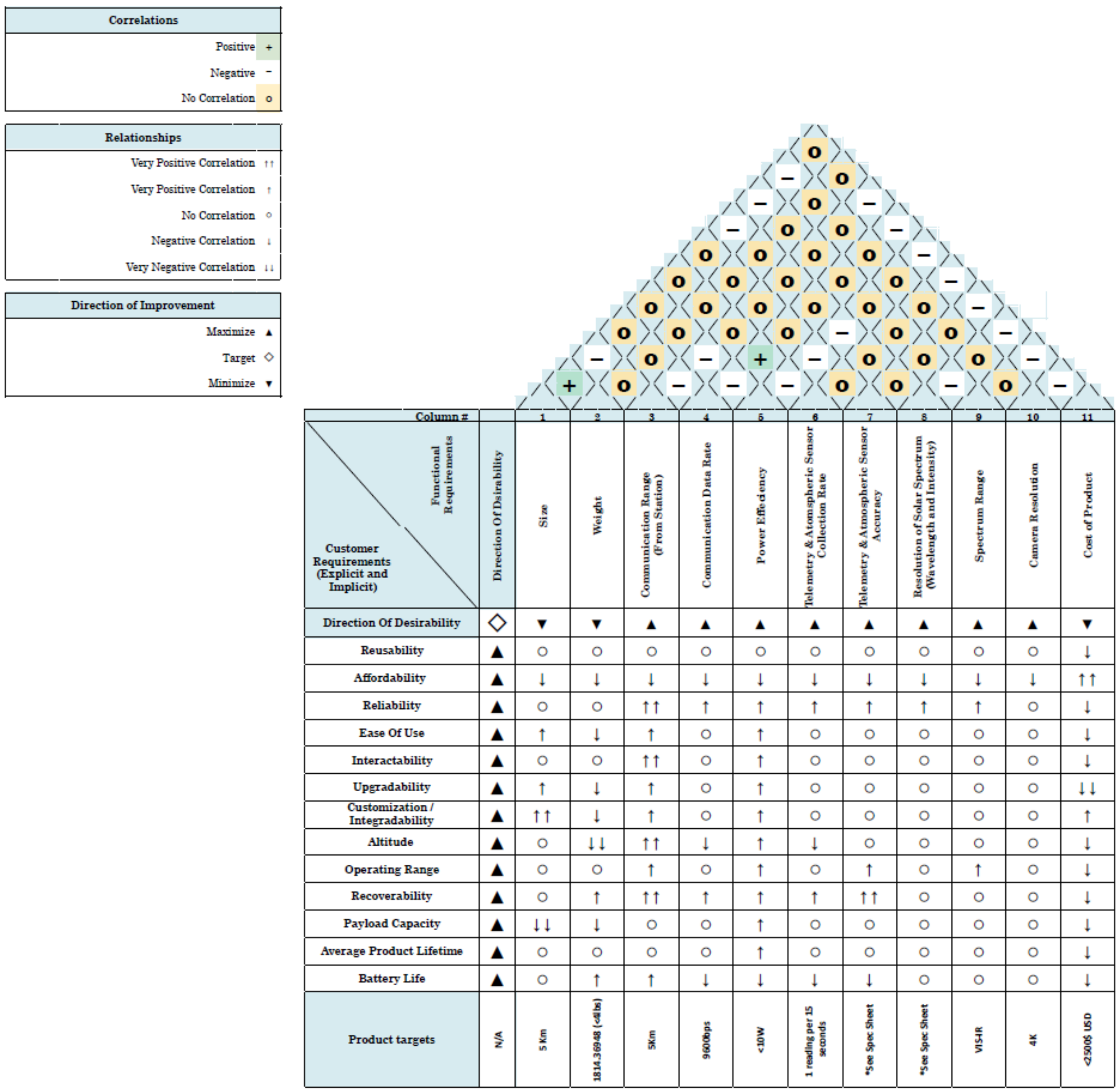
Absorption/Transmission	Transmission grating
Output Type	Spectrograph
Groove Frequency	600 - 1200
Grating Type	Ruled
Dimensions	30 mm x 30 mm
Detector (Photodiodes)	
Incident Area Size	2 mm x 2 mm
Material	Silicon
Wavelengths Detected	500 nm & 750 nm
Telemetry	
Inertial Measurement Unit (IMU)	
Accelerometer Measurement Range	+/-2 to +/-16 *g*
Gyroscope Measurement Range	+/- 125 to +/- 4000 degrees per second (dps)
Accelerometer Sensitivity	0.061 - 0.488 m*g*/LSB (+/-2%)
Gyroscope Sensitivity	4.375 - 140 mdps/LSB (+/-2%)
Bias Instability @ 25 ℃	3 deg/hr
Maximum Power Consumption	5.4 mW
Altimeter	
Calibrated Measurement Range	20 - 110 KPa
Pressure Reading Noise	1.5 - 19 Pa RMS
Accuracy @ -10 to 50 ℃	+/- 0.4 KPa
Pressure Resolution	0.25 - 1.5 Pa
Altitude Resolution	0.0625 - 0.3 m
Maximum Power Consumption	5.04 mW
GNSS System	
Maximum Altitude	50,000 m
Maximum Velocity	500 m/s

Velocity Accuracy	0.05 m/s
Heading Accuracy	0.3 deg
Horizontal Position Accuracy	2.5 - 8.0 m
Max Navigation Update Rate	10 - 18 Hz
Maximum Power Consumption	241 mW
Atmospheric Sensors	
Combined Temperature / Humidity Sensor	
Temperature Measuring Range	-40 ℃ - 25 ℃
Humidity Measuring Range	0% - 100% Relative Humidity
Temperature Accuracy @ 25 ℃	+/- 0.3 ℃
Humidity Accuracy @ 25 ℃	+/- 2% Relative Humidity
Temperature Resolution	0.01 - 0.04 ℃
Humidity Resolution	0.04% - 0.7% Relative Humidity
Maximum Power Consumption	1.8 mW
Anemometer	
Wind Speed Measuring Range	3 - 200 mph
Resolution	2.85 mph
Power Consumption	User Set (~6 µA)
Pressure Sensor	
Pressure Operating Range	10 - 1300 mbar
Temperature Operating Range	-40 - 85 ℃
Pressure Resolution	0.012 - 0.065 mbar
Temperature Resolution	<0.01 ℃
Altitude Resolution	10 cm
Accuracy @ 25 ℃, 750 - 1100 mbar	+/- 1.5 mbar
Accuracy @ -20 - 85 ℃, 300 - 1100 mbar	+/- 2.5 mbar
Temperature Accuracy	+/- 0.8 ℃

Maximum Power Consumption	5.04 mW
Radio System	
Maximum range	150 feet
Communication Rate	100kbps
Supply Voltage	5 V
Logic Voltage	3.3 V
Transmitter Antenna Frequency	915 MHz
Receiver Antenna Frequency	915 MHz
Transmitter Antenna Gain	10 dBi
Receiver Antenna Gain	10 dBi
Camera	
Resolution	Up to 5.3K
Frames Per Second	Up to 60
Zoom (or range of auto zoom)	Up to 2x (1080P)
Video Data Storage (MB)	Up to 1TB
Footage Capture Time (Minutes)	Up to 120
MCU & Related	
MCU Flash Size	4 MB
MCU RAM Size	520 kB
I2C Ports	2
SPI Ports	4
Maximum Power Consumption	1800 mW
SD Card Storage Format	FAT32 (64GB<), EXFAT (64GB>)
Debug Methods	USB to UART / JTAG

2.5 House of Quality

Every design project has to balance a myriad of different desirables. Although there are many ways to represent this balance, a graphical depiction is one of the best methods to do so. We chose the House of Quality to depict the tradeoffs in our project. Refer to *Figure 2.5* for the House of Quality.



Column #		1	2	3	4	5	6	7	8	9	10	11
Functional Requirements / Customer Requirements (Explicit and Implicit)	Direction Of Dsirability	Size	Weight	Communication Range (From Station)	Communication Data Rate	Power Effeciency	Telemetry & Atomspheric Sensor Collection Rate	Telemetry & Atmospheric Sensor Accuracy	Resolution of Solar Spectrum (Wavelength and Intensity)	Spectrum Range	Camera Resolution	Cost of Product
Direction Of Desirability	◇	▼	▼	▲	▲	▲	▲	▲	▲	▲	▲	▼
Reusability	▲	○	○	○	○	○	○	○	○	○	○	↓
Affordability	▲	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑↑
Reliability	▲	○	○	↑↑	↑	↑	↑	↑	↑	↑	○	↓
Ease Of Use	▲	↑	↓	↑	○	↑	○	○	○	○	○	↓
Interactability	▲	○	○	↑↑	○	↑	○	○	○	○	○	↓
Upgradability	▲	↑	↓	↑	○	↑	○	○	○	○	○	↓↓
Customization / Integradability	▲	↑↑	↓	↑	○	↑	○	○	○	○	○	↑
Altitude	▲	○	↓↓	↑↑	↓	↑	↓	○	○	○	○	↓
Operating Range	▲	○	○	↑	○	↑	○	↑	○	↑	○	↓
Recoverability	▲	○	↑	↑↑	↑	↑	↑	↑↑	○	○	○	↓
Payload Capacity	▲	↓↓	↓	○	○	↑	○	○	○	○	○	↓
Average Product Lifetime	▲	○	○	○	○	↑	○	○	○	○	○	↓
Battery Life	▲	○	↑	↑	↓	↓	↓	↓	○	○	○	↓
Product targets	N/A	5 Km	1814.36948 (<4lbs)	5Km	9600bps	<10W	1 reading per 15 seconds	*See Spec Sheet	*See Spec Sheet	VIS-IR	4K	<2500$ USD

Figure 2.5: *House of Quality*

Chapter 10: Administrative Content

10.1 Budget Allocation

The budget for this project was determined in a very liberal manner, as to present a worst-case-scenario cost. For example, the PCB and electrical component budget allows for multiple PCB revisions, thus the $500 allocation. The goal of the team is to never exceed this inflated budget. Refer to *Table 10.1* for the Overall Budget allocation.

Table 10.1: *Overall Budget Allocation*
By Authors

Sub-System	Cost
PCBs / Electrical	$500
Sensors	$200
Sun Spectrometer	$200
Base Station / Antennas	$200
Balloon & Parachute	$400
Payload Box	$150
Ground Equipment	$200
Helium	$500
Total	$2,350

10.2 Bill of Materials

The Bill of Materials itemizes every expense, thus providing a much more tangible method of tracking where money is spent. One may note that the Bill of Materials sums up to much less than the Budget Allocation table. This is because the Budget Allocation table provides a worst-case-scenario cost, while the Bill of Materials provides a more practical cost, given there are no major unexpected expenses. Refer to *Table 10.2* for the Bill of Materials.

Table 10.2: *Bill of Materials*

Component	Quantity	Allocation ($)
MCU	1	$10
Temp./Hum. Sensor	1	$10
Pressure Sensor	1	$10
Anemometer	1	$100
Altimeter	1	$10
GNSS Receiver	1	$30
IMU	1	$10
SD Card (64GB)	1	$40
Custom PCBs	2	$200

Various Electronic Components	10+	$50
Camera	1	$200
Optical Detector	1	$20
Payload Radio Transmitter	1	$30
Payload Antenna	1	$30
Battery	2	$40
Station Radio	1	$100
Station Antenna	1	$50
Balloon	3	$100
Parachute	1	$50
Suspension Line	1	$20
3D Printing Filament	4	$100
Insulation Foam	2	$50
Helium	1	$500
Miscellaneous	1	$200
Total		$1,960

10.3 Distribution of Work

The distribution of work was carefully constructed by discovering each team member's strengths and weaknesses. After this was done, tasks were assigned to members based on how well they meshed with that member's abilities. Each task was also assigned a secondary person to provide a "second pair of eyes" in order to ensure no detail was missed. Refer to *Table 10.3* for the distribution of work.

Table 10.3: *Distribution of Work*
By Authors

Department	Task	Primary Person	Secondary Person
Design / Schematic	MCU	Michael Franz	Sean Rego
	Temperature / Humidity Sensor	Sean Rego	Michael Franz
	Pressure Sensor	Sean Rego	Michael Franz

	Anemometer	Sean Rego	Michael Franz
	Altimeter	Jacob Dorfman	Michael Franz
	GNSS Receiver	Michael Franz	Sean Rego
	IMU	Michael Franz	Sean Rego
	SD Card Slot	Michael Franz	Sean Rego
	Debug Header	Sean Rego	Michael Franz
	5.0 V Power Supply	Jacob Dorfman	Michael Franz
	3.3 V Power Supply	Jacob Dorfman	Michael Franz
	Optical Detector Interface	Lily Sigg	Sean Rego
	Optical Detector Software Interface	Lily Sigg	Hector Parra
	Optical Mirror Layout	Lily Sigg	Lily Sigg
	Payload Radio Transmitter	Jacob Dorfman	Michael Franz
Software	Payload Runtime Software	Hector Parra	Sean Rego
	Payload Sensor Interpretation	Hector Parra	Sean Rego
	Payload Communication Software	Hector Parra	Jacob Dorfman
Board Layout	Main PCB	Jacob Dorfman	Michael Franz
	Power PCB	Jacob Dorfman	Michael Franz
Payload Construction	Payload Antenna Integration	Jacob Dorfman	Michael Franz
	Payload Physical Design	Hector Parra	Michael Franz
	Payload 3D Printing	Hector Parra	Jacob Dorfman
	Payload Insulation	Jacob Dorfman	Hector Parra
	Payload Sensor Integration	Sean Rego	Michael Franz
Base Station	Base Station Antenna Integration	Jacob Dorfman	Michael Franz
	Base Station Radio Integration	Jacob Dorfman	Michael Franz
	Base Station Software Integration	Hector Parra	Jacob Dorfman

Recovered Data	Recovered Data (SD Card) Presentation	Hector Parra	Sean Rego
	Recovered Footage (GoPro) Presentation	Sean Rego	Jacob Dorfman
Tethered Launch	Tethered Launch Coordination	Michael Franz	Jacob Dorfman
	Rapid Deflation Device Implementation	Michael Franz	Hector Parra
	Helium Filling	Michael Franz	Sean Rego
	Launch Train Construction	Sean Rego	Lily Sigg
	FAA Communications	Michael Franz	Sean Rego

10.4 Milestones

In order to ensure timely completion of our project, milestones were established to prevent falling behind and missing critical deadlines. These milestones were chosen to be both punctual and practical. Time was allocated for unexpected delays, yet the spacing between deadlines was minimalized. Our milestones will serve as a guiding beacon of time management, eliminating the possibility of *procrastination.* Refer to *Table 10.4* for our project milestones.

Table 10.4: *Project Milestones*
By Authors

Senior Design 1		
Week	**Date**	**Description**
1	8/19/24 - 8/25/24	- Schedule biweekly meetings with Chan - Continue to complete Chapter 3 - Begin choosing optical detector - Begin hardware diagrams for Chapter 6 - Begin software diagrams for Chapter 7 - Begin ordering development boards
2	8/26/24 - 9/1/24	- Finish preliminary budget - Finish SD I & SD II plan - Finish division of labor - Complete Chapter 3

3	9/2/24 - 9/8/24	- Submit Divide & Conquer - Finish Chapter 6 - Finish Chapter 7 - Begin testing components - Choose an optical detector
4	9/9/24 - 9/15/24	- Divide & Conquer meeting - Finish Chapter 2: Project Description - Finish Chapter 5: Chat GPT - Begin Chapter 8: System Fabrication - Begin Chapter 9: System Testing - Begin Chapter 10: Admin. Content
5	9/16/24 - 9/22/24	- Divide & Conquer revision - Begin PCB Design - Finish Chapter 8: System Fabrication
6	9/23/24 - 9/29/24	- 60 Page Draft Report - Quiz A - Quiz B - Finish Chapter 9: System Testing
7	9/30/24 - 10/6/24	- Quiz C - Quiz D - Finish Chapter 10: Admin. Content - Finish Chapter 11: Conclusion
8	10/7/24 - 10/13/24	- Quiz E - Quiz F - Begin hardware fabrication
9	10/14/24 - 10/20/24	- Quiz G - Begin seeking FAA / UCF tethered launch clearance
10	10/21/24 - 10/27/24	- Finish PCB design - Order PCBs
11	10/28/24 - 11/3/24	- 60 Page Draft Revision - Continue hardware design / redesign
12	11/4/24 - 11/10/24	- Finish Anemometer Mounting
13	11/11/24 - 11/17/24	- Submit Mini Demo Video - Receive PCBs
14	11/18/24 - 11/24/24	- Submit Final Report - Begin PCB assembly

15	11/25/24 - 12/1/24	- Finish hardware design
Senior Design 2		
Week	**Date**	**Description**
1	1/6/25 - 1/12/25	- Schedule biweekly meetings with Chan - Schedule multiple weekly team meetings
2	1/13/25 - 1/19/25	- Finish PCB assembly
3	1/20/25 - 1/26/25	- Begin PCB testing
4	1/27/25 - 2/2/25	- Finish hardware construction & assembly - Finish PCB testing
5	2/3/25 - 2/9/25	- Procure Helium - Final ground test
6	2/10/25 - 2/16/25	**- Tethered launch demonstration**
7	2/17/25 - 2/23/25	- Begin high altitude launch preparation
8	2/24/25 - 3/2/25	- Finish preparation - Finish flight plan
9	3/3/25 - 3/9/25	- Travel to Dayton, Ohio **- Launch & recover Balloon Payload System**
10	3/10/25 - 3/16/25	-Begin Senior Design showcase preparation -Begin editing high altitude video footage
11	3/17/25 - 3/23/25	- Continue Showcase preparation
12	3/24/25 - 3/30/25	- Continue Showcase preparation
13	3/31/25 - 4/6/25	- Continue Showcase preparation
14	4/7/25 - 4/13/25	- Senior Design Showcase
15	4/14/25 - 4/20/25	**- Finished**

Chapter 12: Appendix A - References

[1] A. Long, A. Moreno, S. Rowe, and A. Olivo, “Spectral Telescope for Star Classification by Main Sequence (STSC-MS),” *CREOL Senior Design Summer 2024*, Aug. 2024, [Online]. Available: https://creol.ucf.edu/wp-content/uploads/sites/2/2024/08/2024_Summer_G3_Long_Report.pdf

[2] “Eagle Pro Weather Balloon Kit.” https://www.highaltitudescience.com/products/eagle-pro-near-space-kit

[3] University of Central Lancashire, “UCLan students reach for the skies.literally!,” University of Central Lancashire, May 10, 2023. https://www.uclan.ac.uk/news/high-altitude-balloon-flight

[4] “UAlbany Students experience totality through NASA Eclipse Ballooning Project,” *University at Albany*. https://www.albany.edu/news-center/news/2024-ualbany-students-experience-totality-through-nasa-eclipse-ballooning-project