UCF Senior Design I

Department of Electrical Engineering and Computer Science

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Center for Research and Education in Optics and Lasers

University of Central Florida

Initial Project Identification Document:

Directed High Frequency, Open-air Communication

Group 29

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PROJECT NARRATIVE

In the modern era, where the pace of technical progress has been increasing exponentially, the electromagnetic (EM) spectrum that we depend on for communication is becoming increasingly crowded. AM/FM radio waves, microwaves, UHF and VHF, Wi-Fi, and Bluetooth, are signals that permeate the space we are familiar with in a uniform fashion when the signal broadcasts ideally.

This project proposes a means of communication via infrared laser beam. Additionally, the system should auto-align the sending and receiving instruments to keep a strong signal between the sending and receiving units. If such an analog communication link can be established and maintained, then there exists a means to efficiently transfer data.

The bandwidth of this channel provides a platform wide enough for multiple applications. Currently, specialized imaging sensors are used on drones for agriculture and firefighting while optics help satellites take detailed images of our atmosphere in a myriad of spectrums for use in meteorology. The method of application will vary depending on the size and weight of a receiving module of the communication system.

The prototype solution seeks to provide a pair of micro-controlled optics and sensors that are specific to the bandwidth of infrared light that is accessible to users. The specific portion of the EM spectrum to be used is, as of yet to be determined. The project additionally seeks to prioritize simplicity, wise use of mass and materials and to work reliably at whatever scale can be achieved.

The two core goals are as follows:

1. Establish a directed, high frequency, open-air communication link.
2. If time permits, integrate object tracking to maintain line-of-sight for comm. link.

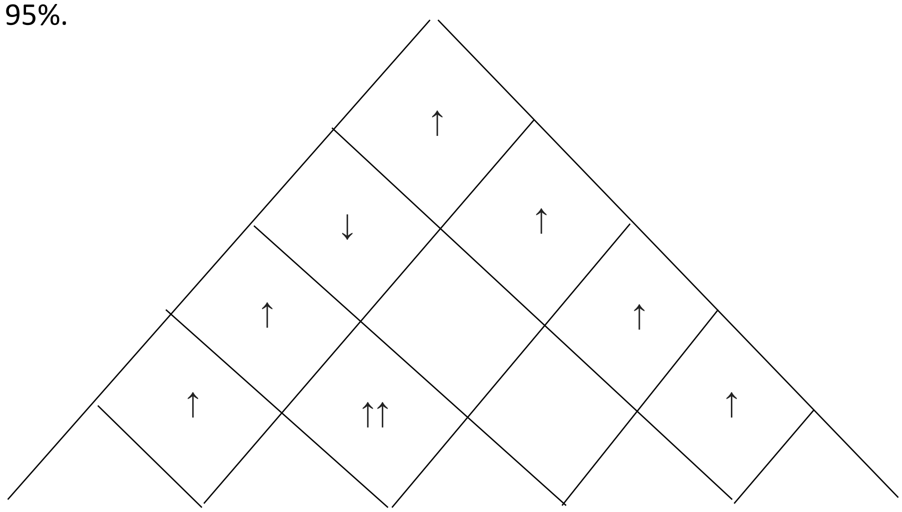
REQUIREMENT SPECIFICATIONS

- The receiver shall be less than 10 lbs.
- The receiver’s form factor must strive to prioritize a low profile.

- The receiving module should be well housed to protect the electronic and optic systems.
- The receiver must prioritize efficient use of energy.
- The communication link will reside within some range of infrared light
- Onboard electronics will be printed on PCB and secured to 3D-printable housing.
- Mainframe should have fiber-optic connectivity to other friendly senders.
- The receiver must be able to communicate if there is a clear line of sight, and resume communication when momentarily interrupted without issue.
- Batteries that power the receiver must be lightweight and provide sufficient throughput as needed.
- Mounting hardware should be easy and stick with adhesive to a smooth surface.
- Prototype will establish a basic link capable of modulating infrared light.
- Optics should be engineered to provide beam shaping of a semiconductor lasing in the infrared spectrum.
- Onboard conversion of the analog to digital data should meet Nyquist sampling requirements.
- CPU onboard receiver can interact with spectrometer for meteorological data, and process analysis and store this information locally, or transmit it back to a paired "lighthouse" through the infrared link.
- Ideally, this system should be lightweight enough to fit on some drones with the option to easily integrate additional hardware such as an imaging sensor and optics.
- Receiving module should be adaptable in the sense that components and instruments can be easily integrated with CPU.

HOUSE OF QUALITY

When building the product and meeting the requirements, we must decide what requirements go with each other and against each other. As shown in Table 1, we measure each of these values with respect to each other. For our prototype we would like to use scaled values for our engineering requirements. For example, for the range of our light we would like to start with 1 ft then expand to 15 ft. We may have the dimensions of the prototype start off as 12*12*12 in and will later scale it to 8*8*8 in. Lastly, we could start off with an accuracy of 80%, and later increase that to 95%.



		Dimensions	Accuracy	Range	Install time	Cost
		-	+	+	-	-
Portability	+	↑			↑	↑
Power	-	↓	↓	↑		↓
Installation	+	↑			↑↑	
Cost	-	↑	↓↓	↓		↑↑
Tasks for Engineering Requirements		< 8*8*8 inches	>95%	Light: 15 feet Laser: 150 feet	< 20 minutes	< $150

Table 1: House of Quality

LEGEND

= no correlation

↑ = positive correlation

↑↑ = strong positive correlation

↓ = negative correlation

↓↓ = strong negative correlation\

+ = high value

- = low value

PROJECT BLOCK DIAGRAM

As shown in Figure 1, the project's main hardware components are listed below. The NIR Spectrometer records the pressure and temperature, and this data is communicated to the microcontroller, which in turn stores the data. When a connection is made, currently stored data is converted to analog and transmitted via high frequency communication to the mainframe computer, where it is received, converted into digital data, and stored. To communicate with the receiver, the mainframe computer encodes data into high frequency communication and transmits it, where it is then decoded and stored by the receiver's on-board microcontroller.

In Figure 2, it's shown how the software will operate within the system. The software of the transmitter and receiver is separated by the red lines, which communicate between the two parts of the system. The microcontroller will ensure that all of these commands are followed and the laser gets transmitted through the following components in the system. If the data has been found, then we would send it to the digital to analog converter. Then, we would need to would need to wait until the DAC encrypts the data so it can be sent over to the receiver via laser. Once the data has been sent over successfully it would go through an analog to digital converter so that the data can be decrypted into its original format. If the data has done this successfully, then an LED will turn on to indicate that the code has ran successfully and the display will update.

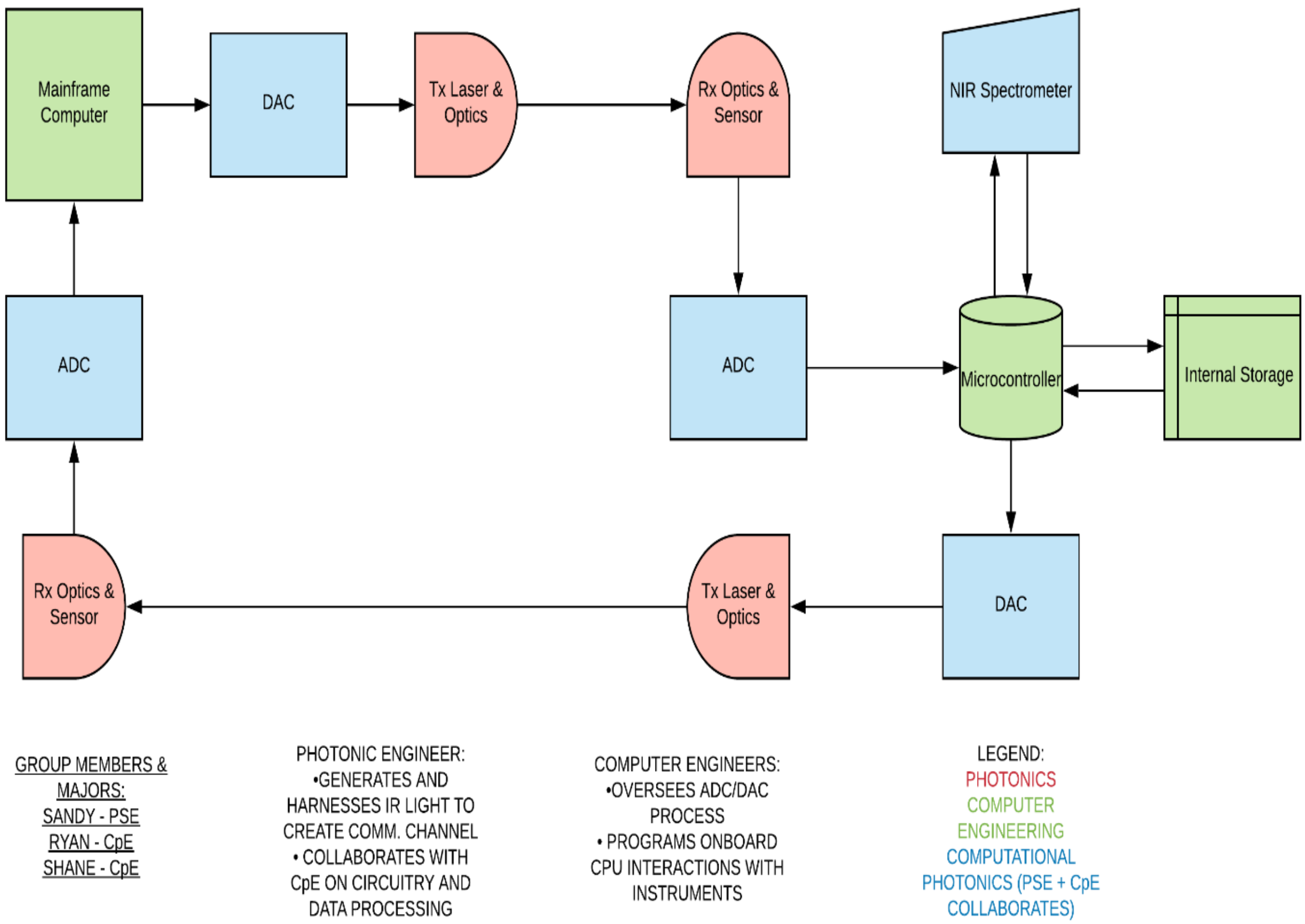


Figure 1: Project Block Diagram

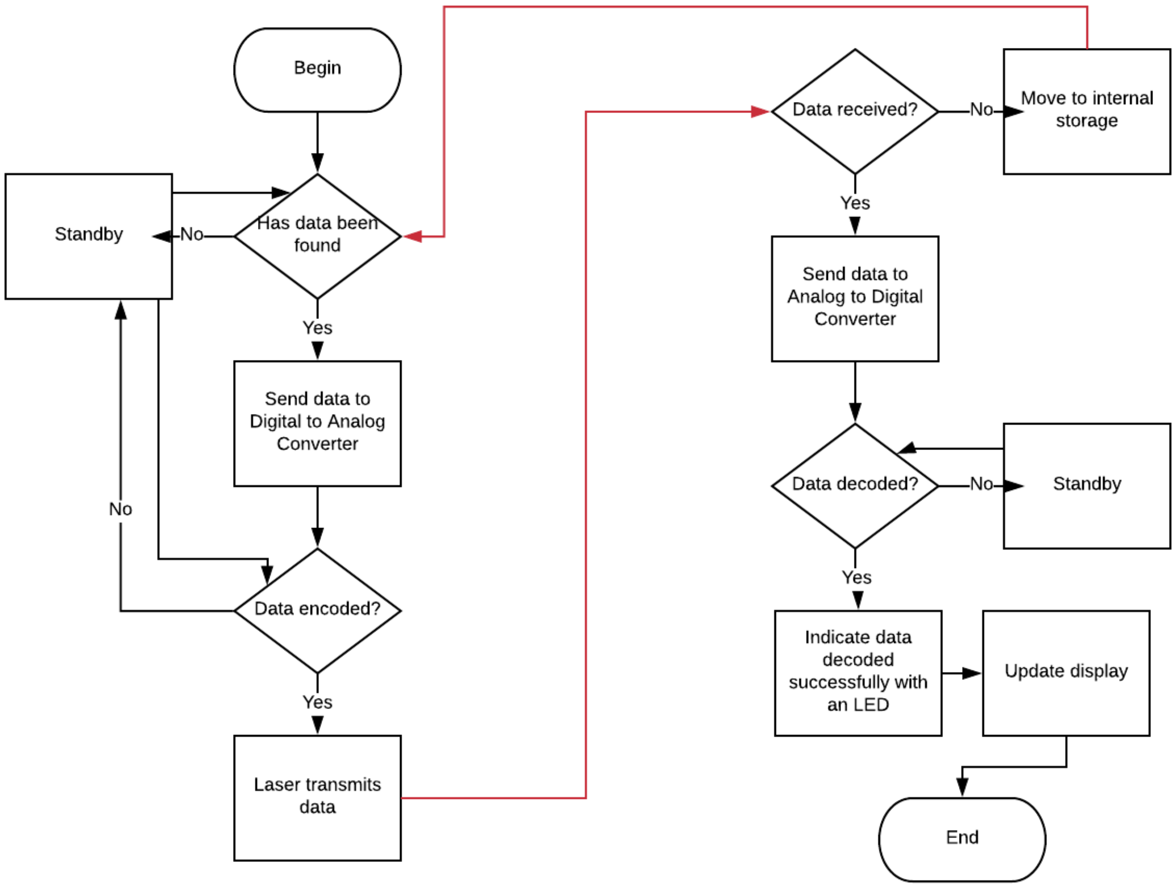


Figure 2: Software flowchart

ESTIMATE PROJECT BUDGET AND FINANCING

Table 2 lists some commercially obtainable hardware and other project components that can be used to increase the feature set of the project.

The project budget will be continually updated according to need, mostly concerning budget and time constraints.

When mature, the project budget will present an accurate cost analysis when the course of project development reaches completion.

Project Budget		
Component	**Quantity**	**Price**
Microcontroller	2	$20
PCB manufacture	4	TBD
Optoelectronic sensors	2	TBD
Battery	1	TBD
Laser diodes	4	TBD
Cables & Accessories		$50
Analog to Digital Converter	2	TBD
Spectrometer	1	$8500
Benchtop DC Power Supply	1	$85
Optical components		TBD
Electrical components		TBD
Optics gimble	2	TBD
Total Price:		> $8,550

Table 2: Budget Table

INITIAL PROJECT MILESTONE FOR BOTH SEMESTERS

As shown in Table 3, is our planned schedule for our overall process of what tasks we need to complete and how long it will take to complete them. The only tasks that are still to be decided are the tasks in Senior Design 2. Once we complete of final draft for senior design 1, we can plan out our new milestones for Senior Design 2.

Task	Time needed	Dates
Senior Design 1		
Develop Project Idea	2 weeks	8/20-9/2
Submit Proposal	1 week	9/7-9/14
Review Existing Projects	2 weeks	9/2-9/14
Update Proposal	1 week	9/20-9/28
First Draft	7 weeks	9/14-11/2
Final Draft	12 weeks	9/14-12/3
Prototyping	4 weeks	9/28-10/26
Research PCB	4 weeks	9/28-10/26
Research Microcontrollers	4 weeks	9/28-10/26
Research SolidWorks	4 weeks	9/28-10/26
Research Signals & Systems modulation	4 weeks	9/28-10/26
Research Sensors	4 weeks	10/26-11/23
Research Lasers	4 weeks	10/26-11/23
Research Optics	4 weeks	10/26-11/23
Research Light Sources	4 weeks	10/26-11/23
Order Parts	3 weeks	12/3-12/24
Build Prototype	TBD	TBD
Senior Design 2		
Test Prototype	TBD	TBD
Finalize Report	TBD	TBD
Finalize Presentation	TBD	TBD
Finalize Project	TBD	TBD

Table 3: Milestone Table