Critical Design Review

Sponsor: SOUTHCOM

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Low-Cost Passive Aircraft Detection System

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Motivation & Background

- Many countries struggle to detect aircraft near borders due to expensive radar systems ($20M+), leaving "dead zones" vulnerable to illegal activity (e.g., smuggling, drones).
- Our senior design project aims to develop a low-cost, stealthy, and reliable solution to increase border security.
- Sponsored by Roy H. Wubker Jr. (DoD SOUTHCOM), with initial guidance on RF detection and an exploration into optical alternatives.

Our Solution

- Active radars (which emit RF signals) are costly, both to buy, and maintain over time.
- We propose passive radar that listens to existing signals (e.g., FM radio, GPS) reflected from targets, making it harder to detect and requiring less power.
- Passive radars are also much cheaper and easier to maintain over time.
- To optically enhance the system, we propose a super-resolution three-camera array.
- This will combine the images of three cost-effective cameras, capturing far away objects, to produce an output with detail on par with expensive long-distance cameras.

Project Basic Goals

- The successful detection of a metal sphere using passive detection.
- Measure antenna radiation pattern and classical range measurement
- Arrange 3 low-cost cameras in a simple and stable array configuration.
- Capture an image at a distance of 1, 10, and 20 meters and effectively enhance the resolution of the image using image processing techniques.
- Use code to do image processing and to create a super resolution image.
- Build a lightweight and reliable software system that connects the spectrum analyzer to a web interface.
- Create a basic user interface that displays aircraft signal data in real time, including location, signal strength, and detection source
- Develop a background service that runs independently to collect and clean signal data from the SDK
- Format and store incoming data in a way that can be quickly used by the front end without slowing the system down

Project Advanced Goals

- The system should be able to detect an aircraft in flight. This will prove that our passive detection system is working as intended.
- The system should be self-sustaining. If the system were to be deployed in the field, it should be able to provide its own power. This may be done via solar, wind, or other types of power generation depending on the deployment location.
- The time it takes to deliver the information from the system to the user should be relatively quick. This will ensure that our system is actually viable and worth implementing.
- The device should have a housing that allows it to operate in adverse conditions. Primarily heat and humidity.
- Design lens systems such that a very wide view, wide view, and telephoto lens system are able to be applied to the camera array.
- Enhance our 3 cameras with lenses that will help the process of super resolution effectively at a distance.
- Capture multiple images of a drone or other object through our camera array and use image processing techniques to create a super resolution image that may be run through a detection program/software.
- Design a way to place the lenses in front of the cameras and ensure proper optical alignment.
- Integrate real-time WebSocket support so that aircraft signals are shown instantly on the map as they are detected
- Use signal processing filters to clean up noisy data and reduce false detections
- Develop logging features that keep track of signal patterns, errors, and system health in case of a failure or disconnect
- Build the system with cross-device compatibility so it works on both desktops and mobile phones without major changes

Project Stretch Goals

- The system should be easily implemented and easily manufacturable. The main goal of this project is to provide a low-cost solution which means ease of use and construction is important to consider.
- The system should be connected with other systems to form an array. This will allow for accurate localization and will help the user determine the speed, direction, and location of any aircraft within the detection distance.
- The system should be completely autonomous. This will allow the user to “set it and forget it” and will alert them of possible incursions within their airspace.
- The system should incorporate a false alarm feature.
- Create or utilize a database that can characterize aircrafts and identify the type of plane or drone that is entering the range of the antenna. The system should have the ability to easily install and uninstall enhancements depending on the user's needs. This will be vitally important when it comes to selling the unit. Depending on the user's needs or surrounding environment, they may or may not want certain add-ons or enhancements.
- Design a sturdy, stable, and environmentally protected housing for the entire device.
- Design a connecting unit that allows the unit to be attached to a vehicle, such as an airplane, for mobile image capture.
- Design a housing for the lens system that allows for easy swapping in case the object is at a different distance.
- Incorporate a phase correction plate to account for any aberrations due to the environment.
- Upgrade optical components to a higher quality to further improve the performance of the assembled system
- Combine the RF device and camera array into a synergistic system for optimal performance in aircraft detection.
- Include signal classification features that can help identify different types of aircraft or filter out non-aircraft signals
- Build a simple database to log past detections and allow users to search or review older signal events
- Create a dashboard interface that summarizes total detections, time active, and any alerts or events

Project Objectives for Basic Goals

- Research, select, and buy quality and cost effective materials and components to create the device
- Ensure proper calibration of spectrum analyzer
- Test all components once they have arrived to ensure they function properly.
- Measure range of detection by using a second antenna.
- Use a second antenna to find the effective beam pattern of the antenna.
- Research and purchase low cost, low resolution cameras to include in the array and ensure they can easily be integrated with our devices.
- Test multiple array configurations and shapes and observe which configuration and camera spacing results in the best image after image stitching.
- Use wood, cardboard, or foam to put the camera array on so we can ensure that they are aligned properly and stable.
- Connect the cameras to a computer via a USB connection.
- Write and test code using python to do image processing techniques and create a higher resolution image out of the many that were captured.
- Use Zemax to design a lens system that will allow for quality image capture at 100 yards and account for possible aberrations that we may encounter.
- Use Node.js and Express to set up the server and connect it to the front end
- Design a responsive and clean UI using HTML, CSS, and JavaScript with a focus on readability
- Write code that pulls signal data from the SDK using a background service and sends it to the web interface
- Test the real-time signal display using simulated or replayed spectrum analyzer data
- Keep the code organized with clear comments and folder structures to make future updates easier

Project Objectives for Advanced Goals

- Create an algorithm that differentiates noise from aircraft.
- Test the prototype at Dade Collier Airport to see if we can detect passively
- Research means to power the unit autonomously and integrate it (phase 2)
- Test the amount of computer power and latency to process data.
- Increase efficiency of detection algorithms to decrease power draw.
- Purchase more of the low cost, low resolution cameras to arrange into a larger array configuration.
- Research a way to effectively connect all the cameras into a more cohesive system.
- Use the sign outside of the L3 Harris building on campus to test our camera array at a distance of 100 yards and see if we can produce a more clear image at that distance.
- Based on the separations of the cameras in the array, design a housing for multiple lens systems that can be easily attached to the array and are properly aligned.
- Research and work with CREOL professors to understand how a phase correction plate works and how to properly incorporate it into our design to produce the best possible image.
- Connect the software system to a live spectrum analyzer device using its SDK
- Test signal filtering methods and select the best one for reducing false positives
- Set up WebSockets for constant updates between the backend and the front end
- Collect user feedback on the UI and make changes to improve clarity and performance

Project Objectives for Stretch Goals

- Develop a robust enclosure to protect the camera system from harsh environments.
- Integrate with an aircraft mounting system and optimize the system for aerial imaging. Also conduct airborne tests.
- Research and invest in more cameras with better frame rates, resolutions, and the ability to sync capture.
- Create a larger array that has the capability to incorporate more cameras and lens systems to increase the potential of the super resolution system.
- Research and invest more time into super resolution algorithms including algorithms that make use of AI and deep learning.
- Create a larger database of aircraft and drones that may be called upon when an anomaly appears in the area. This can be used to compare what was captured and detected with the camera array with previous detections or, if enhanced with AI, what the deep learning was trained on.

Engineering Requirements

Parameter	Specification
Signal receive and detection time	5 min or less
Airspace coverage	10-12 miles at 12,000 feet
Detection Range	50m to 50km
Size	<1m^2
Cost	<$6500

Engineering Requirement	**Parameter**	**Specification**
Camera(s)	Resolution Pixel Count Frame Rate Color Shutter Type	1MP 1280x800 100 fps Monochromatic Global Shutter
Camera Array	**Effective FOV** **Image Overlap**	**0.5-5 degrees** **>30%**
Super Resolution Algorithm	**Final Image Quality**	**3MP count**
Lens System	**System Length** **Object Size at 100 Yards Away**	**5x Magnification**

Hardware Overview

- Log-periodic antennas (e.g., Aventas AX-37A):
  - Wide frequency range (300–3000 MHz)—ideal for unpredictable reflections.
  - Good forward gain and low noise for accurate detection.
  - Compact design and rugged construction suitable for challenging environments.
  - Selected as the best trade-off of performance, bandwidth, and size.

Antenna Type	Frequency Range	Beam Pattern	Gain (dbi)	Cost
Half Wave	3K to 300G	Omni	2.15	$80.00 - $200.00
Half Wave Folded	3K to 300G	Omni	4	$509.00
Microstrip	915-930 Mhz	Broad	2	$14.00
Collinear	896 - 970 Mhz	Omni	5	$85.15
Yagi-Uda	880 - 960 Mhz	Omni	12.2	$247.00
Log Periodic	300 - 3000 Mhz	Omni	6	$0.00

Hardware Overview

- Signal Hound BB60D chosen due to:
  - Lowest cost, aligning with project budget constraints.
  - Compact, USB-powered, and low power consumption (6 watts).
  - Compatible with Linux for portable processing (e.g., Raspberry Pi, Nvidia Jetson).
  - Free software with SDK for advanced detection algorithms (e.g., AI/ML integration).
  - 27 MHz RTBW is acceptable for the targeted frequency range.
  - Good dynamic range and sensitivity for detecting low-power signals from aircraft.
  - Best trade-off of performance, portability, and cost for the project's needs.

Spectrum Analyzer	Frequency Range	DANL dBm/Hz	RTBW	Dynamic Range	Cost
Tektronix RSA306B	9 Khz to 6.2 Ghz	-160	40 MHz	-160 dBm to 20 dBm	$6490
Siglent SSA3032X-R	9 Khz to 3.2 Ghz	-165	40 MHz	60 dB	$6545
Signal Hound BB60D	9 Khz to 6 Ghz	-158	27 Mhz	-150 dBm to 10 dBm	$0.00
Keysight N9023B PXA	2 Hz to 55 Ghz	-167dBm	2 Ghz	-170 dBm to 30 dBm	$207292.56

Hardware Overview

- Intel NUC 13 NUC13ANHi7:
  - High-performance Intel Core i7 (12 cores, 16 threads) with 16GB RAM.
  - Fast 512GB NVMe SSD for high-speed data logging and analysis.
  - Supports complex software (e.g., MATLAB, GNU Radio) for RF analysis.
  - Excellent connectivity (USB, Thunderbolt 4, Ethernet) for integrating with RF equipment.
  - Compact form factor and power-efficient (~90W) for field deployment.
  - Expandable and versatile with Windows/Linux support and hardware acceleration (Iris Xe).
  - Chosen for its best mix of performance, portability, and compatibility with our signal processing needs.

Feature	**Intel NUC 13 (NUC13ANHi7)**	**Raspberry Pi 5**	**NVIDIA Jetson Nano**
Processor	Intel Core i7-1360P (12-core, 16-thread)	Quad-core Cortex-A76	Quad-core Cortex-A57
RAM	16GB DDR5	Up to 8GB LPDDR4X	4GB LPDDR4
Storage	512GB NVMe SSD	microSD or SSD (via adapter)	microSD or SSD (via adapter)
GPU	Intel Iris Xe Graphics	Broadcom VideoCore VII	NVIDIA Maxwell (128 cores)
Power Consumption	~90W	~5W	~10W
OS Support	Windows 11 Pro, Linux	Raspberry Pi OS, Linux	Ubuntu, Linux
Price	$0	$69.49	$224.99
Best Use Case	**High-performance data processing**	Low-power, simple data collection	AI-enhanced RF processing

Hardware Overview

- **Why Samsung Galaxy S24**:
  - **Direct-to-cell satellite messaging now**, future voice/data support for wider coverage.
  - **High-performance Snapdragon 8 Gen 3 processor** and large, high-resolution display.
  - **Long battery life** and future-proofed hardware for seamless aviation data tracking.
  - **Best balance** of hardware, connectivity, and support for continuous access to flight data via Starlink.

Feature	Samsung Galaxy S24 Ultra	Apple iPhone 15	Google Pixel 8 Pro	Older Android/iPhones
Starlink Direct-to-Cell Support	**Yes (Texting now, voice/data future)**	Yes (Texting now, voice/data future)	No (Wi-Fi only)	No (Wi-Fi only)
Processor	Snapdragon 8 Gen 3	Apple A17 Pro	Google Tensor G3	Varies
RAM	12GB	6GB	12GB	4GB-8GB
Display	6.8” AMOLED (120Hz)	6.1” OLED (120Hz)	6.7” OLED (120Hz)	Varies
Battery Life	~14-16 hours	~13-15 hours	~12-14 hours	Lower than modern flagships
Starlink Wi-Fi Support	Yes	Yes	Yes	Yes
Price	$0	$729.99	$599.99	<$500

Hardware Overview

- **USB (Universal Serial Bus)**:
  - High data rates (USB 3.0: 5–10 Gbps), suitable for complex data.
  - Provides **power** (up to ~5W), eliminating the need for separate power supplies.
  - Robust, versatile, and standardized across platforms.
  - Direct compatibility with the chosen **spectrum analyzer** and **Intel NUC**.
  - **Chosen for its superior bandwidth, versatility, and compatibility** with our high-speed data needs.

Protocol	Power output	Bandwidth	Interface Compatible
I2C	1-5mW	400 KB/s	No
UART	3.3-150mW	10 Mbp/s	No
USB	.5-4.5W	5 - 10 Gbp/s	Yes

Hardware Overview

- Starlink (Low Earth Orbit Satellite Service):
  - Global coverage; operates on multiple bands (Ku, Ka, V) with high data rates and low latency.
  - Suitable for remote areas, eliminating need for cell towers or wires.
  - Drawbacks: Higher power consumption (10–100W) and rain fade susceptibility (weather interference).
  - Upcoming Starlink-to-Mobile Integration:
    - Direct satellite connection for modern smartphones—low power consumption, global reach.
    - Simplifies system design and reduces infrastructure needs.
  - Chosen Solution: Starlink offers the best balance of global coverage, speed, and future-proof connectivity despite higher power needs.

Protocol	Power Consumption	Download Speeds	Upload Speeds	Latency	Coverage
4G LTE	2 - 10 W	5 - 150 Mbp/s	1 - 50 Mbp/s	20 - 50ms	Near cell tower
Starlink	10 - 100 W	50 - 250 Mbp/s	10 - 40 Mbp/s	20 - 50ms	Worldwide

Hardware Overview

- Westinghouse 100-Watt Power Station:
  - Lightweight (3.75 lbs) and highly portable for mobile radar deployment.
  - Sufficient battery capacity (155Wh) for low-power radar needs.
  - Affordable, making it cost-effective for prototyping and eventual deployment.
  - Solar-ready for renewable, self-sustaining operation with continuous recharging.
  - Multiple outputs (USB, DC, AC) for powering all necessary devices.
  - Compact design and low output capacity match the system's modest energy requirements.
  - Why Chosen: Provides the optimal balance of portability, cost, solar functionality, and power output for passive radar use.

Feature	**Westinghouse 100W**	**EF ECOFLOW RIVER 2 Pro**	**EF ECOFLOW DELTA Max 2000**	**Jackery Explorer 300**
Battery Type	Lithium-Ion	LiFePO4	LiFePO4	Lithium-Ion
Battery Capacity	155Wh	768Wh	2016Wh (Expandable)	293Wh
Power Output (Rated/Surge)	150W / Not specified	800W (1600W X-Boost)	2400W / 5000W	300W / 500W
Solar Input	Yes	220W max	800W max	100W max
Weight	3.75 lbs (Lightest)	17.2 lbs	48 lbs (Heaviest)	7.1 lbs
Price	$0(cheapest)	$379	$1299(most expensive)	$259
Dimensions (inches)	7.4 x 6.6 x 3.7	10.6 x 10.2 x 8.9	19.6 x 9.5 x 12	9.1 x 5.2 x 7.8
Best Use Case	Small devices, ultra-light travel	Mid-range power needs, tools, RVs	Home backup, high-power appliances	Camping, small device backup

Hardware Overview

- Arducam OV9281
  - Good starting resolution (1280 x 720) – will allow for a higher quality final output
  - Global shutter – better at capturing scenes involving motion
  - 100 fps
  - USB connection
  - Monochromatic

Feature	Arducam OV9281	IMX219 8MP	See3CAM_ CU135	Rasp. Pi CM3
Resolution	1280x720	3280x2464	4208x3120	4608x2592
Shutter Type	Global	Rolling	Rolling	Rolling
Max Frame Rate	100 fps (720p)	30 fps (1080p)	60 fps (1080p)	100 fps (720p)
Pixel Size	3 um	1.12 um	1.1 um	1.4 um
Connection Type	USB 2.0	MIPI CSI	USB 3.0	MIPI CSI
Price	~$50	~$35	~$100	~$40
Best for Motion Detection	Yes, global shutter prevents motion blur	No, rolling shutter leads to motion blur	No, rolling shutter leads to motion blur	No, rolling shutter leads to motion blur
Super Resolution Feasibility	Good, multiple cameras with high frame rates	Possible, limited by rolling shutter	Possible, limited by rolling shutter	Possible, limited by rolling shutter

Hardware Overview

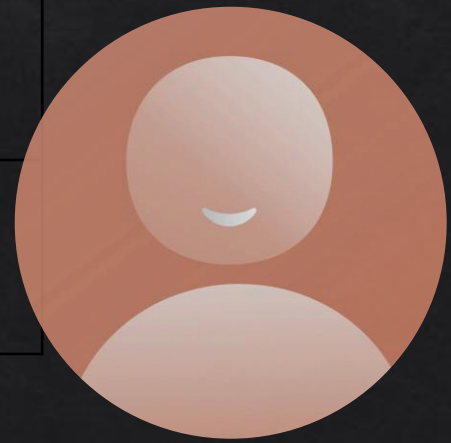
- Lens System Types
  - 5x magnification at an object distance of ~100m.
  - Small focal length to keep design compact
  - 0.5-5 degree FOV to create ~1m of object space

Feature	Telephoto Lens	Wide-Angle Lens	Adjustable Zoom Lens	Fisheye Lens	Aspheric and Custom Lenses
Focal Length Range	**100mm-600mm**	10mm-35mm	24mm-200mm	Wide-ranging	Wide ranging
Positive Features	Minimizes perspective distortion and high precision with long distances	Wide field of view to give peripheral information	Best used for moving objects	Field of view 180 degrees or more	Minimizes spherical and chromatic aberrations
Negative features	Narrow field of view	Barrel distortions and low magnification	Focal length changes causing image blur and chromatic aberrations	High distortions	Can be expensive

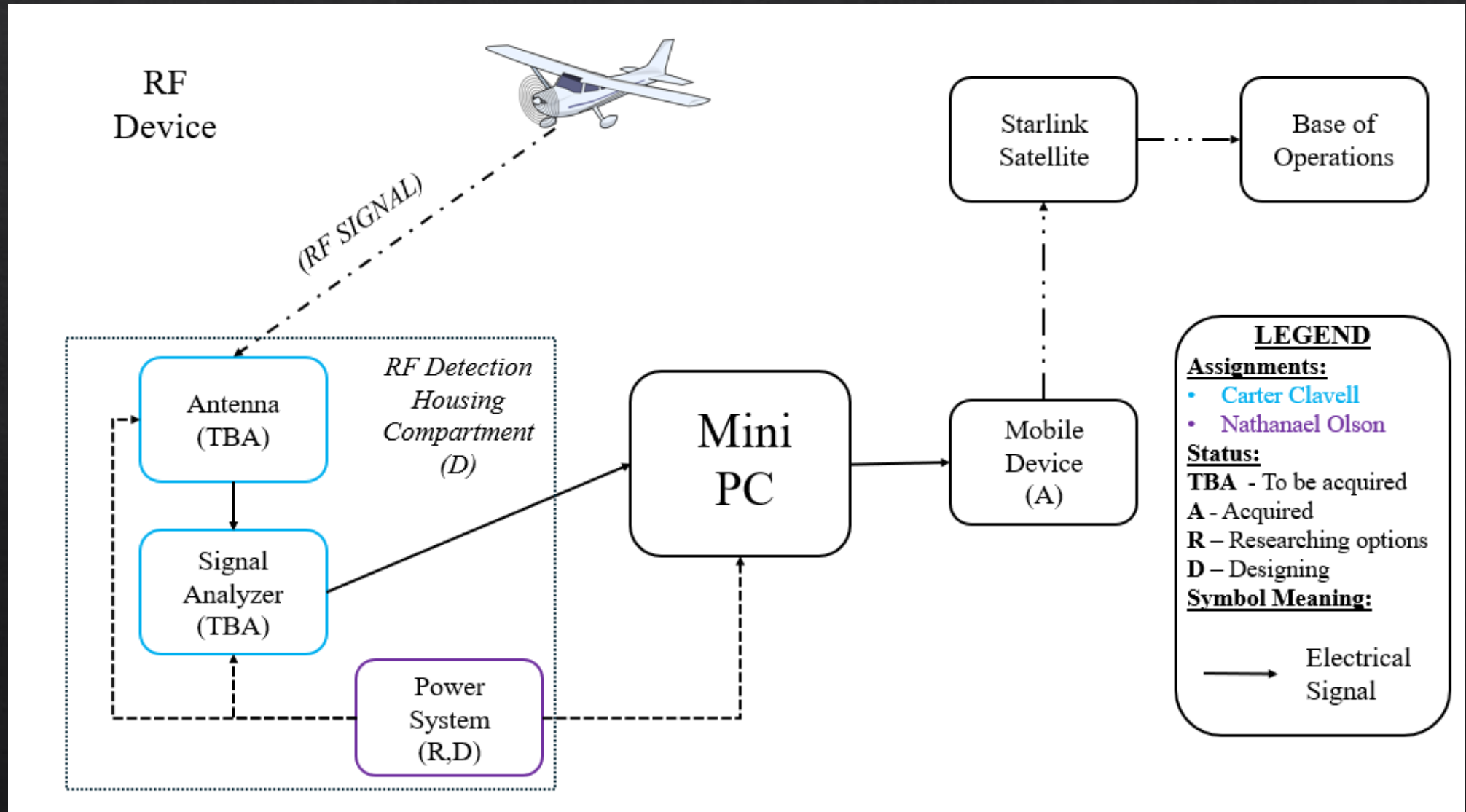
Hardware Overview

- Pluggable 7-port USB Hub
  - Reduces bottlenecking affect when operating all 3 cameras at the same time
  - Higher number of ports means our 3 cameras will get sufficient power
  - Connects easily to computer

USB Hub	# of Ports	Bandwidth	External Power	Bandwidth for each port	Best for multi-camera use	Price
Plugable 7-Port	7 - USB 3.0	5 Gbps	60 W	Highest stability for each port	Best for multiple camera setup	~$50
StarTech 7-Port	7 - USB 3.0	5 Gbps	36 W	Higher stability for each port	Best if all ports are not used, 4-5 cameras	~$60
Anker 10-Port	10 - USB 3.0	5 Gbps	60 W	Lower bandwidth per port	Lots of ports, but when all are in used, performance issues	~$40
StarTech 4-Port	4 - USB 3.0	5 Gbps	None	Lower bandwidth and possible power issue risk		~$35



Hardware Design



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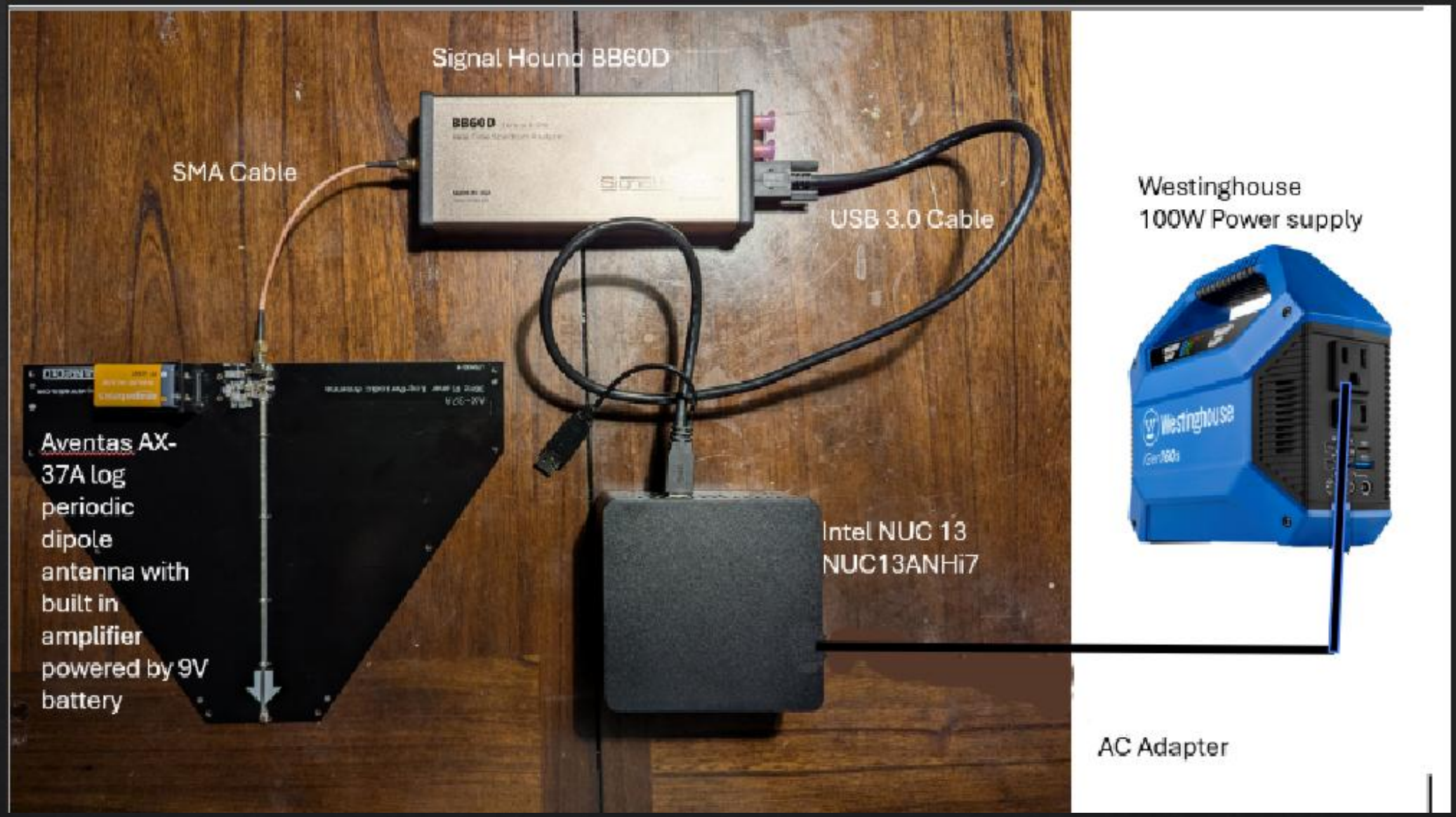
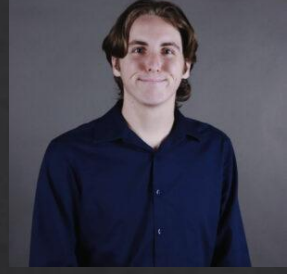
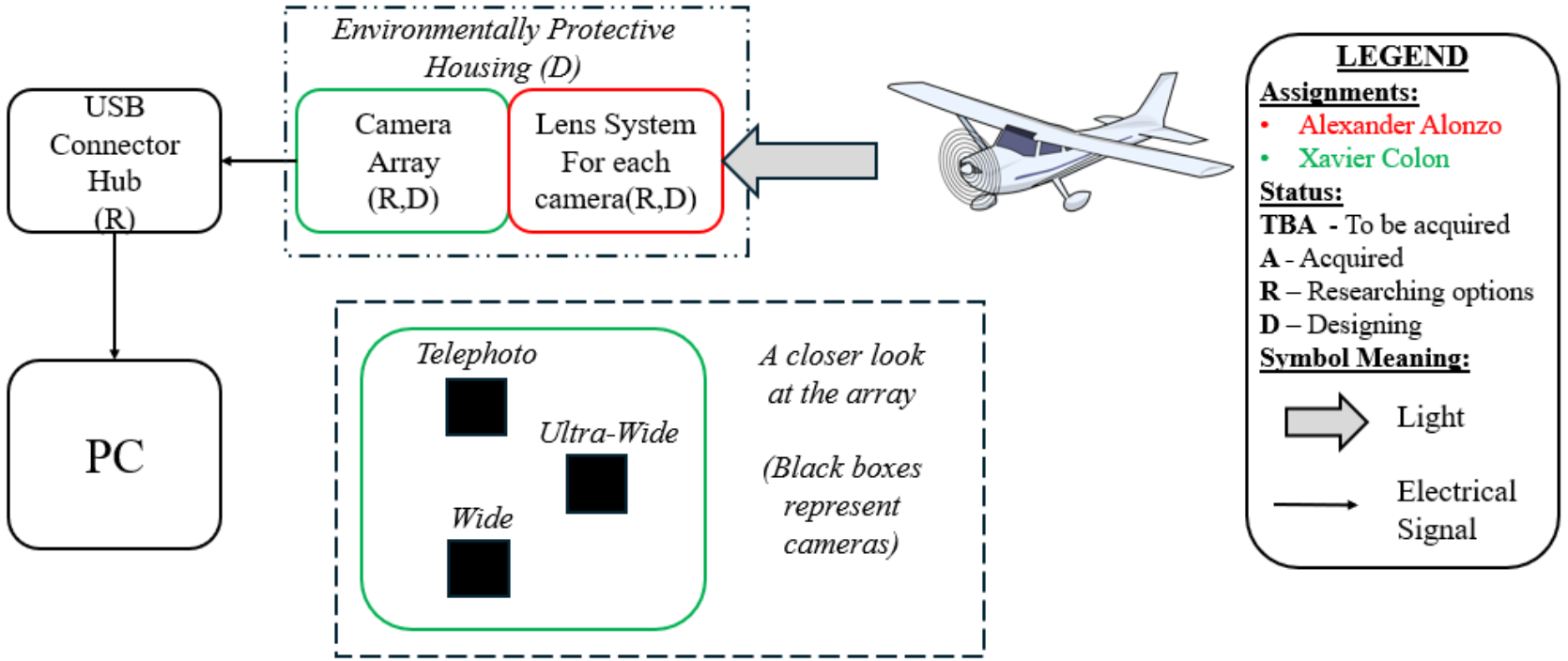




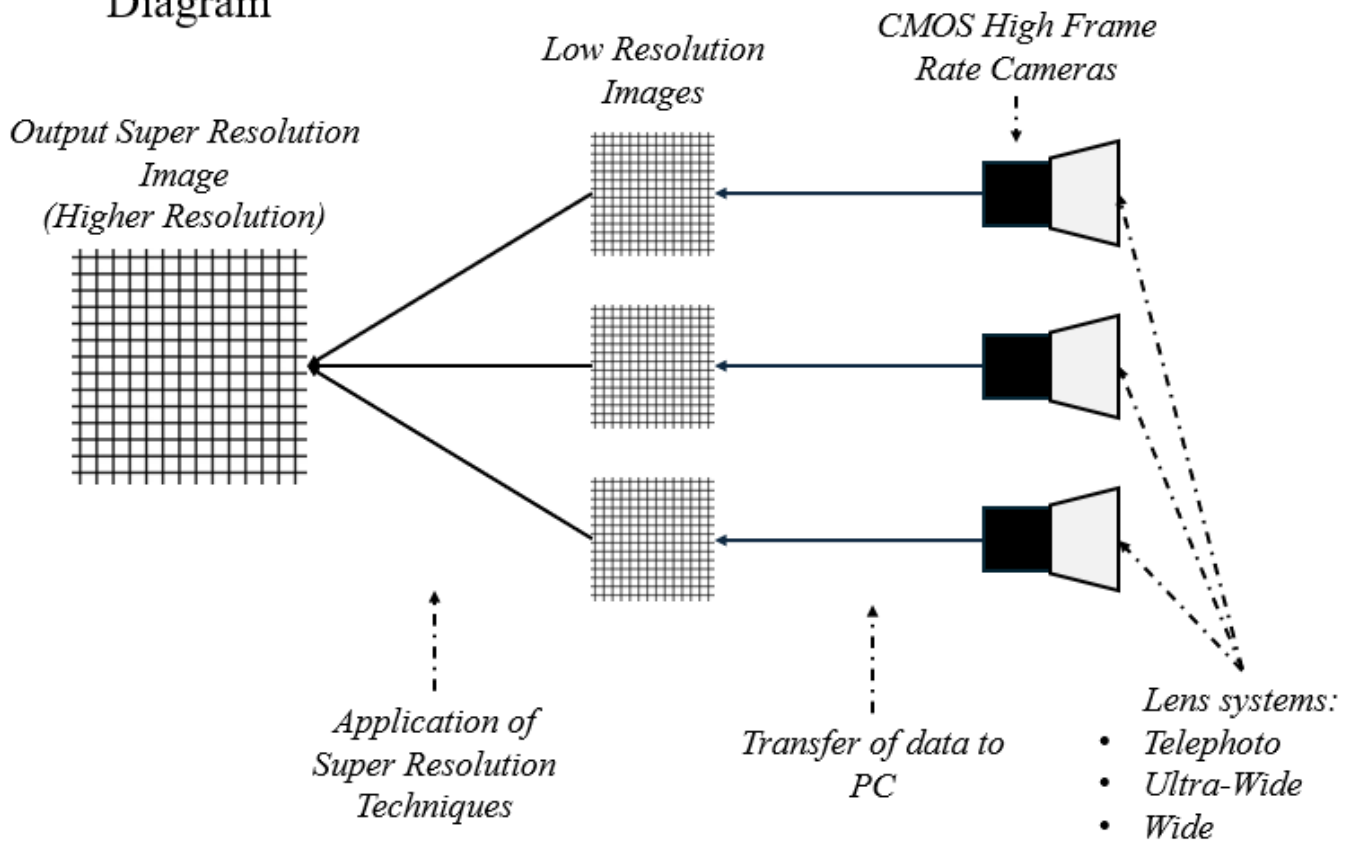
Hardware Design

Camera Array System



Hardware Design

Schematic Diagram



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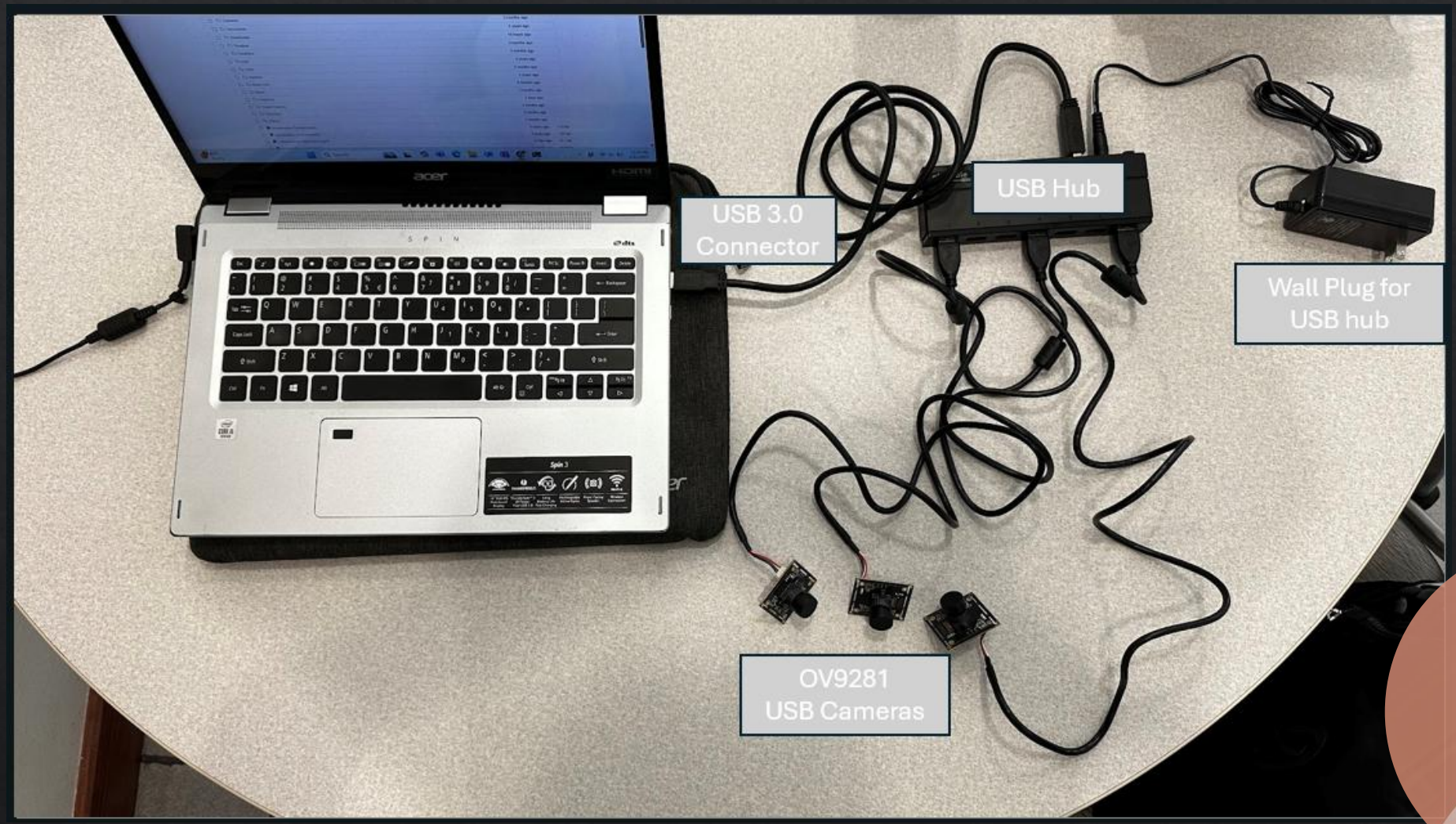

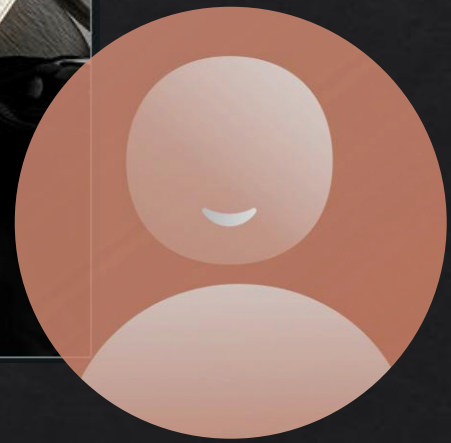

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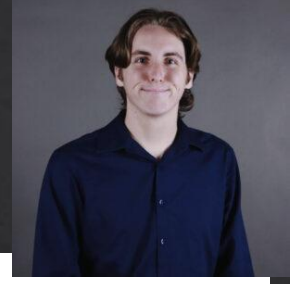

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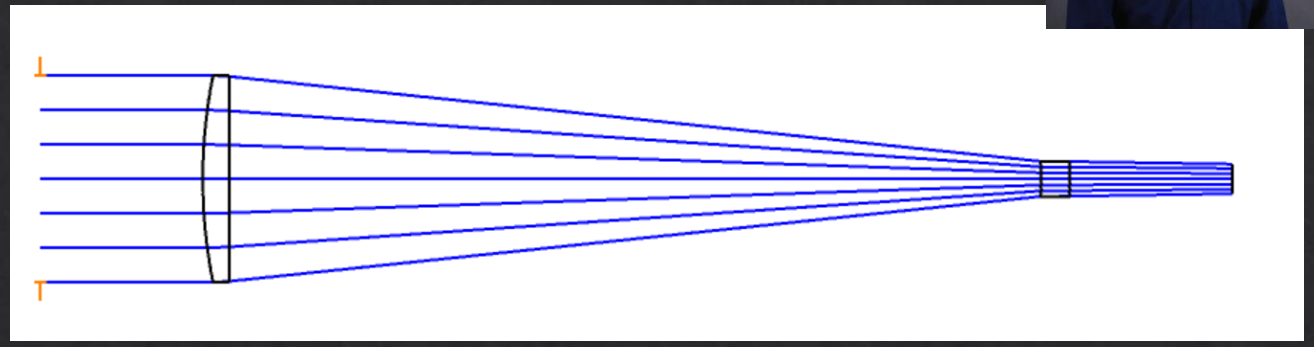
1	STOP Standard		Infinity	20.000	
2	Standard	125 Lens 1 S1	64.400	3.300	BK7
3	Standard	Lens 1 S2	Infinity	100.0...	
4	Standard	-25 Lens 2 S1	-19.620	3.500	N-SF11
5	Standard	Lens 2 S2	Infinity	20.000	
6	IMAGE Standard		Infinity	-	



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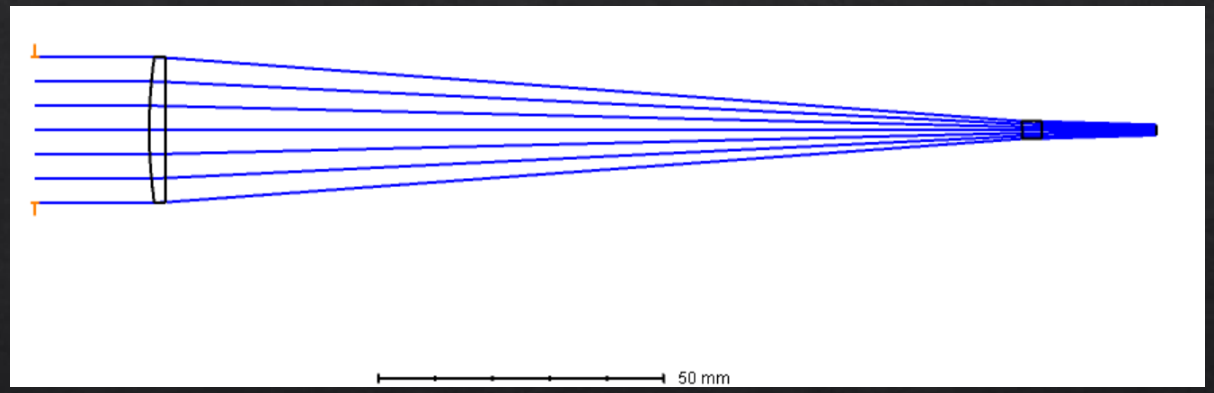
1	STOP Standard		Infinity	20.000	
2	Standard	175 Lens 1 S1	90.100	2.900	BK7
3	Standard	Lens 1 S2	Infinity	150.0...	
4	Standard	-35 Lens 2 S1	-27.470	3.500	N-SF11
5	Standard	Lens 2 S2	Infinity	20.000	
6	IMAGE Standard		Infinity	-	



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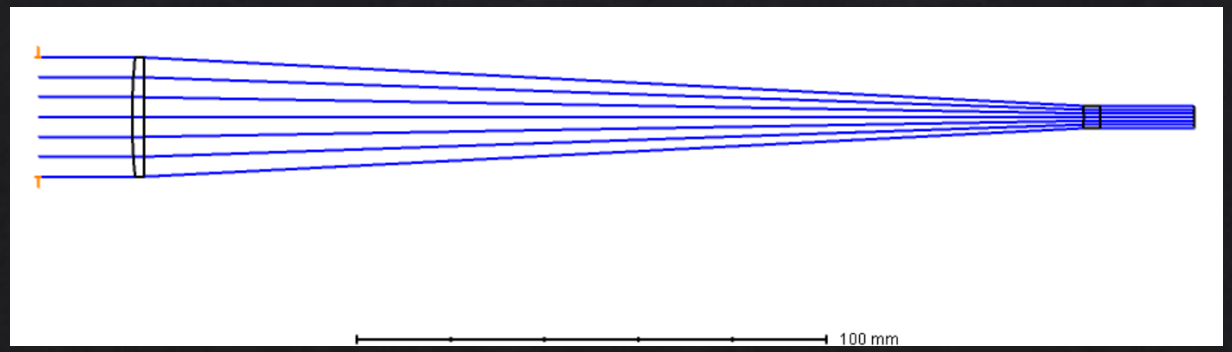
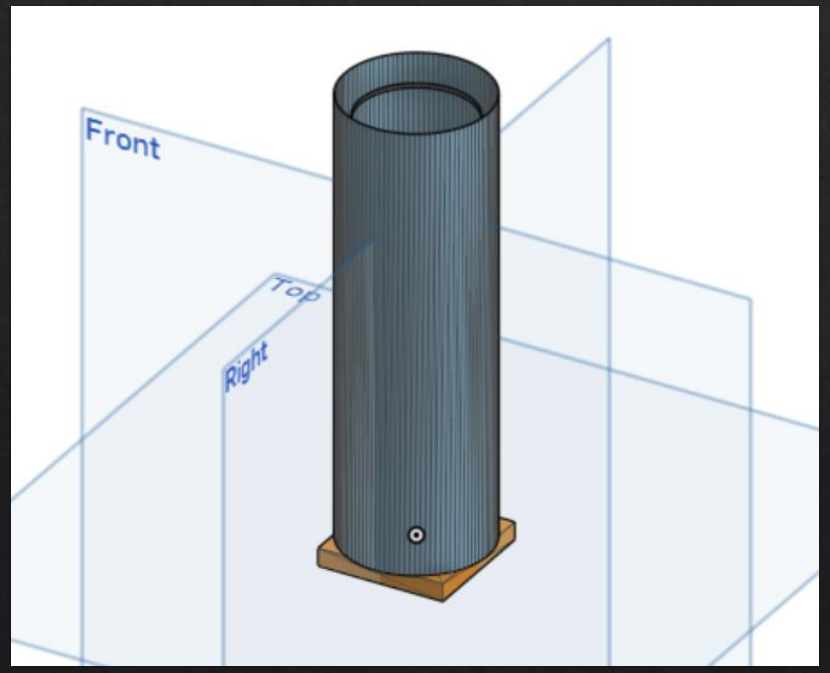
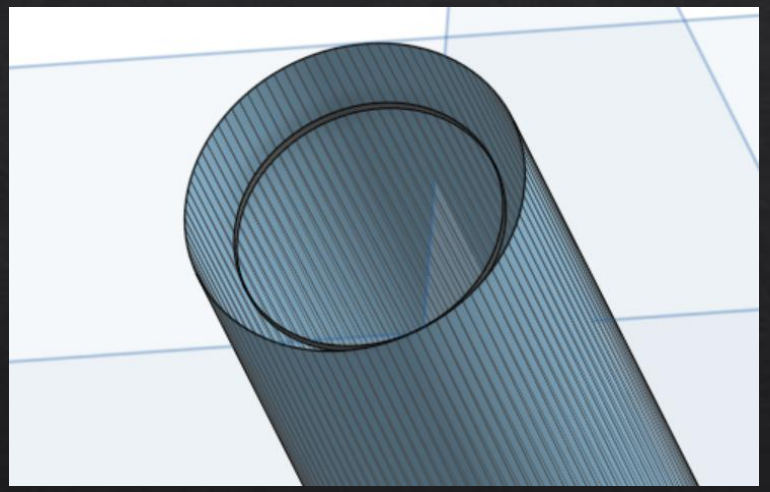
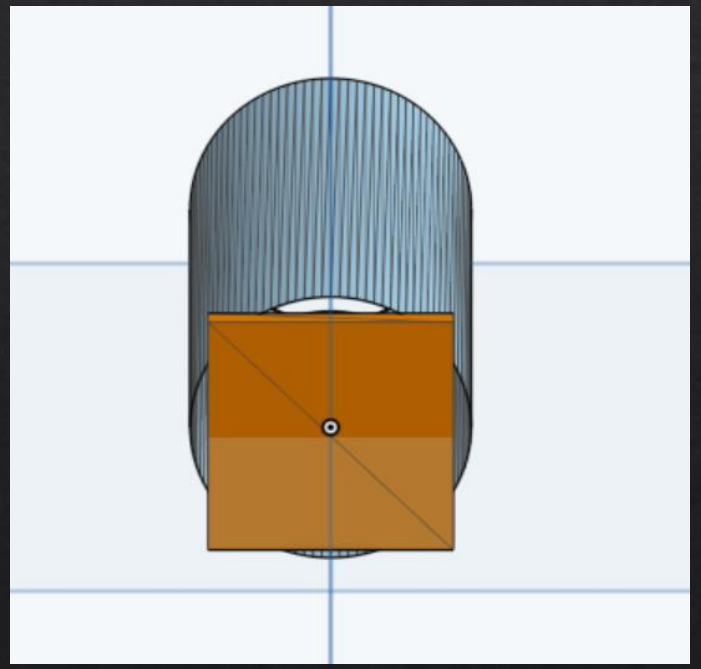
1	STOP Standard		Infinity	20.000	
2	Standard	250 Lens 1 S1	128.800	2.600	BK7
3	Standard	Lens 1 S2	Infinity	200.0...	
4	Standard	-50 Lens 2 S1	-25.840	3.500	BK7
5	Standard	Lens 2 S2	Infinity	20.000	
6	IMAGE Standard		Infinity	-	



Hardware Design







Software Overview

Front-end Frameworks

	Vanilla JS	React	Angular
Type	Language	Library	Framework
Complexity	Simple	Moderate, component-based	Complex, structured, and opinionated
Setup Needed	None	Moderate	High
Performance	Moderate, inefficient	High	Good
Ideal Use Case	Small Projects	Medium to large projects	Large-scale enterprise applications

React-

- Front-end Library
- Requires a bit of setup, but easy to develop with.
- Easy to expand web application with reusable components.
- Great performance for medium sized web applications.

Software Overview

Non-Relational Databases

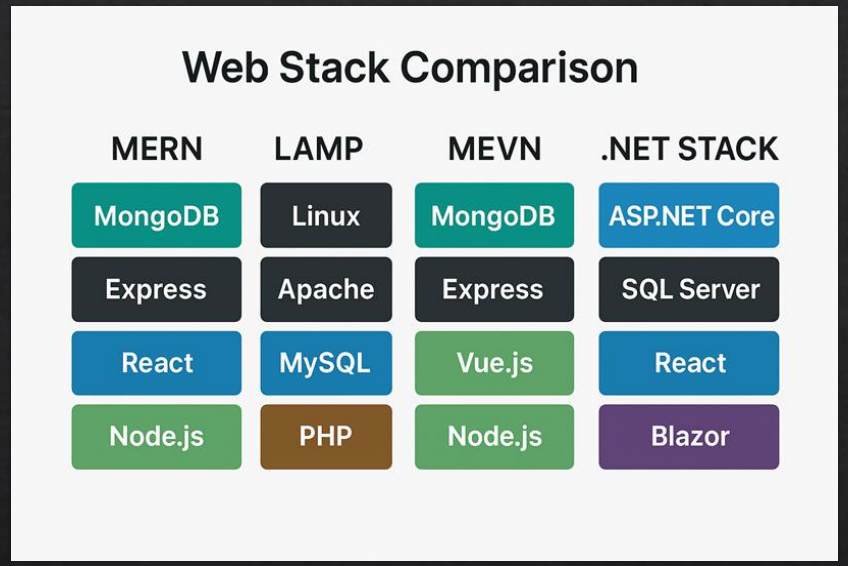
	MongoDB	Cassandra	Redis
Efficiency	High	High	Very High
Scalability	Good for large datasets	Excellent	Limited (memory-based)
Flexibility	Dynamic schema	Wide column store	Key-value storage
Query Performance	Moderate	Limited	Minimal
Geospatial Support	Yes	No	No
Data Consistency	Eventual Consistency	Eventual Consistency	Not ACID-compliant

MongoDB-

- Document-based approach makes it easy to store and retrieve information.
- Scales well horizontally, which could help with storing information from multiple sensor nodes.
- Great geospatial indexing capabilities.
- Good balance between flexibility and performance.

Software Overview

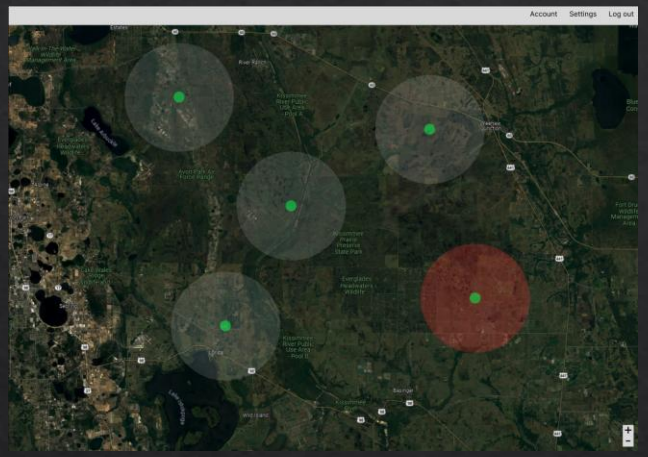
Premade Web Stacks

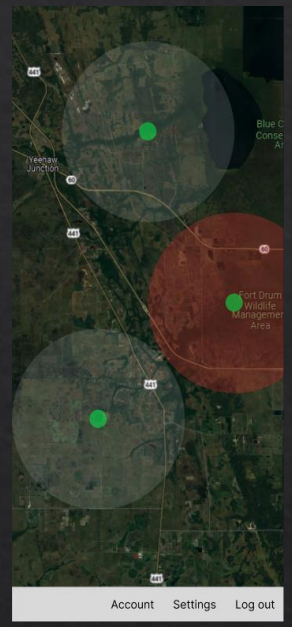


MERN-

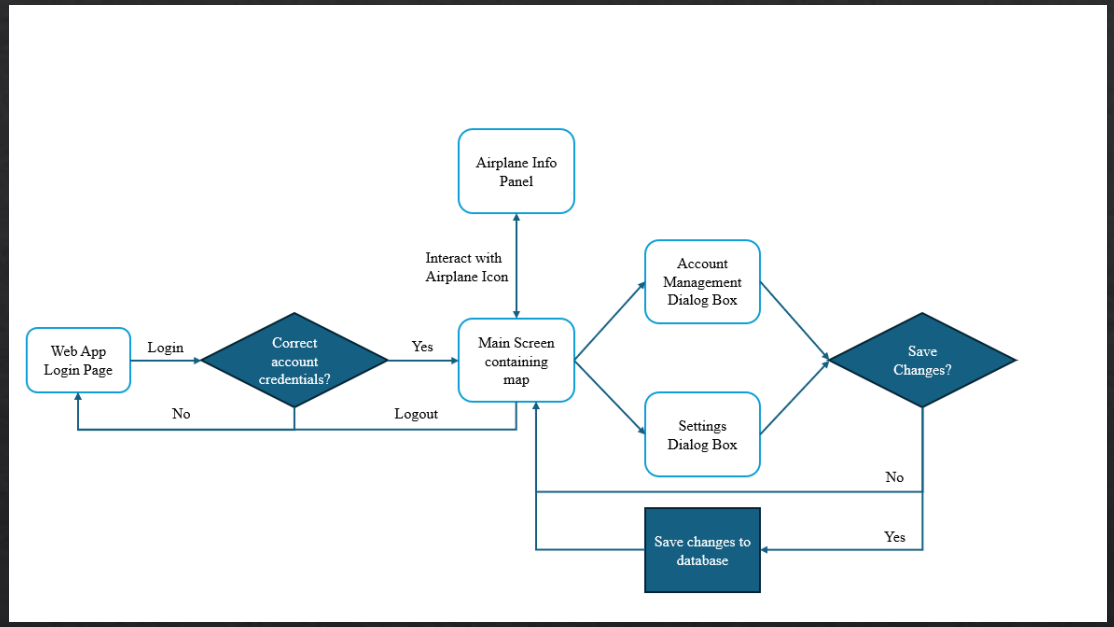
- Since MERN includes both React and MongoDB, our choices for front-end and database, it made the most sense to use the commonly used MERN stack.
- Uses Node.js and Express for the back-end server.

Software Design





Front-End Design Drafts



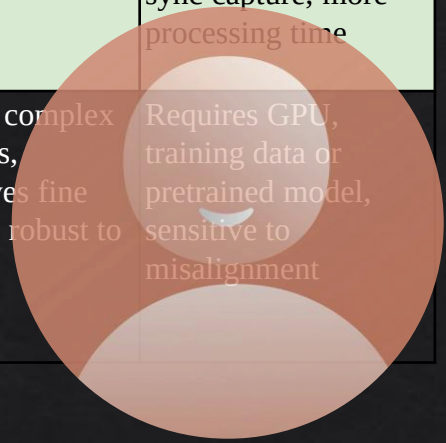
User-Flow Diagram

Software Design

Multi-Image Super Resolution

- Doable with MATLAB & Python
- Doesn't require as much data as ESRGAN
- Still produces decent results but requires precise alignment of cameras as well as a precise way to synchronize the capture

Method	Type	Input	Computational Cost	Image Quality	Pros	Cons
Nearest Neighbor	Single Image, Interpolation	1 Image	Very Low	Poor	Fast, Simple, zero processing time	Blocky artifacts, jagged edges, poor detail retention
Bilinear	Single Image, Interpolation	1 Image	Low	Fair	Smooth results, slightly better than NN	Blurry, soft edges, still loss of detail
Bicubic	Single Image, Interpolation	1 Image	Moderate	Good	Smoother than bilinear, better edges	Blurs fine details, no resolution gain
MISR (Multi-Image SR)	Multi-Image & Alignment	Multiple Images Aligned	High	Very Good	Uses actual new info from image shifts	Requires accurate image alignment, sync capture, more processing time
ESRGAN	Multi-Image & Deep Learning	Multiple Images Aligned	Very High	Excellent	Learns complex patterns, preserves fine details, robust to noise	Requires GPU, training data or pretrained model, sensitive to misalignment



Software Overview

Image Object Detection Models

	TensorFlow	YOLO (You Only Look Once)	Detectron2	OpenCV
Speed	Moderate-High	Very High	Moderate	Very High
Accuracy	High	Moderate-High	Very High	Low-Moderate (Less accurate for complex scenes
Ease of Use	Moderate (requires setup)	Moderate (if using pre-trained models)	Moderate-Easy	Easy, straightforward setup and deployment
Deployment Environments	Web, mobile, cloud	Embedded devices, desktop applications	Server, desktop, research environments (heavy computational demand)	Embedded systems, desktop applications
Ideal Use Case	Industrial automation, traffic surveillance, object tracking	Real-time video analysis, surveillance, frones	High-accuracy applications, scientific image analysis	Rapid prototyping, low-resource devices, simple detection tasks.

YOLO-

- Known for high performance and real-time object detection capability.
- Great where rapid-response times are crucial.
- Moderate ease of use using pre-trained models.
- High accuracy for our use-case.

Prototype and Testing

- Hardware and software testing
- Performance evaluation
- Success
- Difficulty, problem and proposed solution

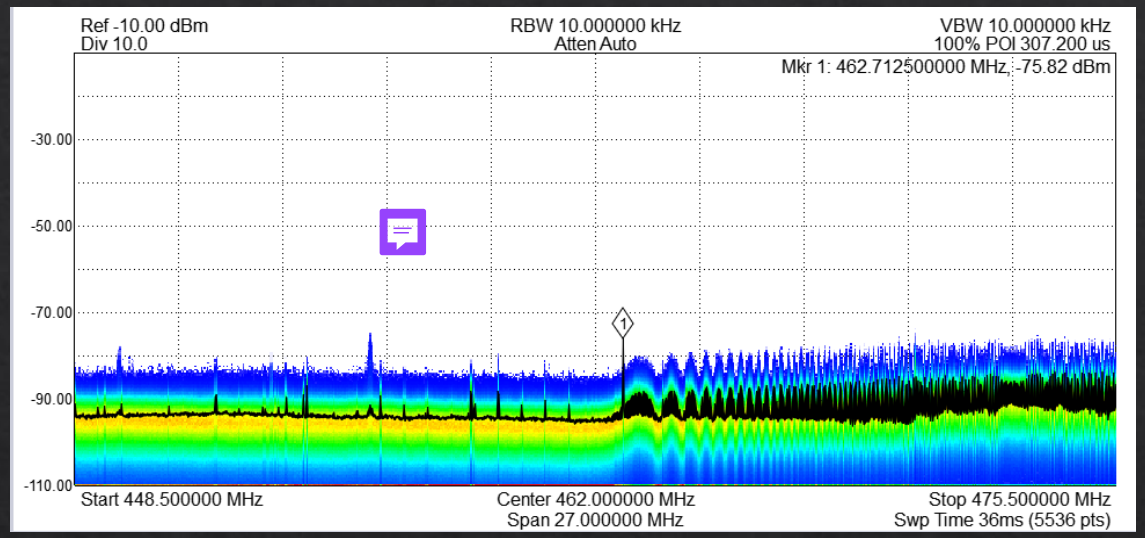
Prototyping & Testing – Hardware Testing

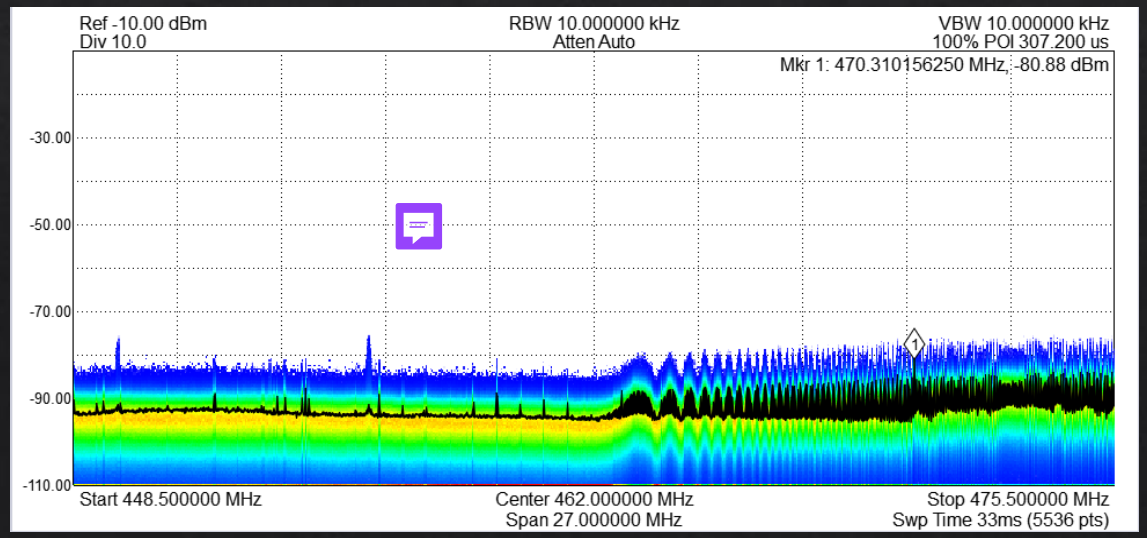
For our hardware testing, we needed to create a standard procedure. Initially we wanted to test the range of something simple such as a walkie-talkie radio. It is safe to transmit at all times and will give us a good idea of how far we can detect.

1. First, we setup the such that the antenna was laid horizontal to the ground plane. In our initial testing, we found that horizontal polarization works best for our use case.
2. Next, we will have to find an area that is relatively low noise and where we could place the antenna at a decent height. Given that it is in a tree it will be important for us that the antenna is high up.
3. Finally, we will have someone move a known distance and activate the walkie-talkie as it will show up on our spectrum analyzer at a known and given frequency.
4. From there, we will have the person move farther back so that we can see wha the decay of the signal is.

Prototyping & Testing – Performance Evaluation & Successes

- First, we went to George R. Kennedy memorial Park in Edgewater Fl. The reason being is there was wide open space, and it was relatively low noise.
- From here we were able to do some range testing with the walkie talkie.
- We were able to detect the walkie talkie from 1 – 1.5 mile away. Which is a great success as it will only get better as we refine our test procedure to reflect the environments it will be in.
- Another success is that the whole spectrum was visibly disturbed when an airplane flew by which is a good sign as we make a more sophisticated algorithm to detect aircraft.
- A little less than we were hoping, which was about 5 miles.
- On the images on the right, we can see the walkie talkie turned on and off at 1 mile away.





Prototyping & Testing – Difficulties and Solutions

Difficulties

- As previously mentioned, the ranges we were experiencing were a little bit shorter than we had wished for.
- No enclosure
- Not enough data
- Unable to pick up drone controller from a mile away.

Solutions

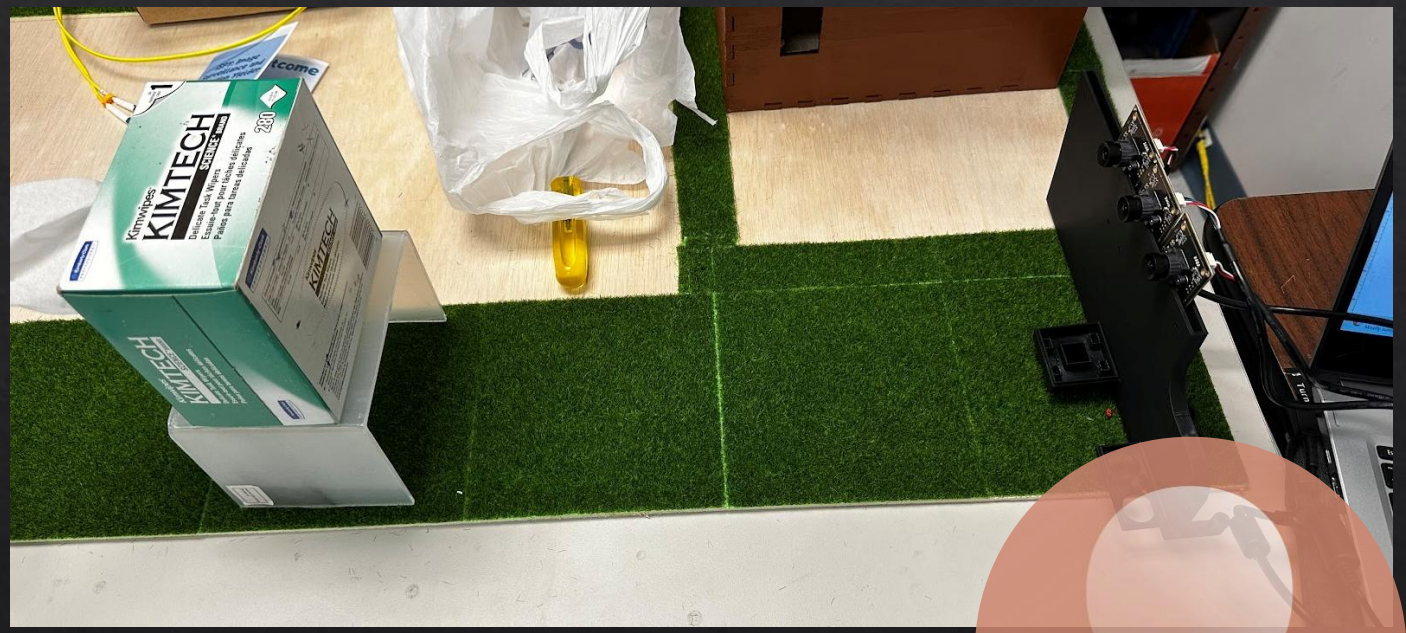
- To help with our range, we have some test times setup where we will set the antenna higher in the air. We have just purchased an electricians 8 foot ladder which should help. We also considered using UCF parking garages as they will easily get us up to tree heights.
- We plan to fabricate an enclosure as we leave the prototyping stage
- We need more data if we plan to detect an aircraft which means we will have to go to very RF quiet environments such as collier dade airport.

Prototyping & Testing – Hardware Testing

For the camera array, we tested a preliminary version of the super resolution code with 3 objects in the lab. The goal was to see how each object would affect the image post-enhancement.

Notes:

- Cameras were aligned and held using a plastic block
- Objects were placed at the same position
- This testing was conducted without our designed lens systems



Prototyping & Testing – Hardware Testing

Since this iteration of the code relied on image stitching techniques, we can see that the results are not quite as good as we'd like.

To solve this issue, we are still testing different ways to perform super resolution techniques.

The integrity of the object is maintained so at a baseline, you can identify the type of aircraft in your airspace, and depending on the aircraft, could make out markings on the aircrafts body.

Prototyping & Testing – Hardware Testing

For the lens systems, we gathered lenses from the lab and arranged them such that their magnification value was 5x.

Here we show that magnification by using a laser and sending its light through the lens system. After measurement, it was confirmed to be about 5x magnification.

This same strategy was applied to the other 2 systems and this allowed us to develop the lens casings for each system.

Prototyping & Testing – Difficulties and Solutions

Difficulties

- Still need to test with lens systems
- Alignment
- Some problems when dealing with certain objects (like bottle of sprite)
- Testing at long range may produce more unknowns that we will have to adjust to

Solutions

- Ensure lens systems are compatible with cameras
- Create stable and aligned holder for cameras
- Test with drones or small planes to better define success criteria
- Conduct many tests and further develop code

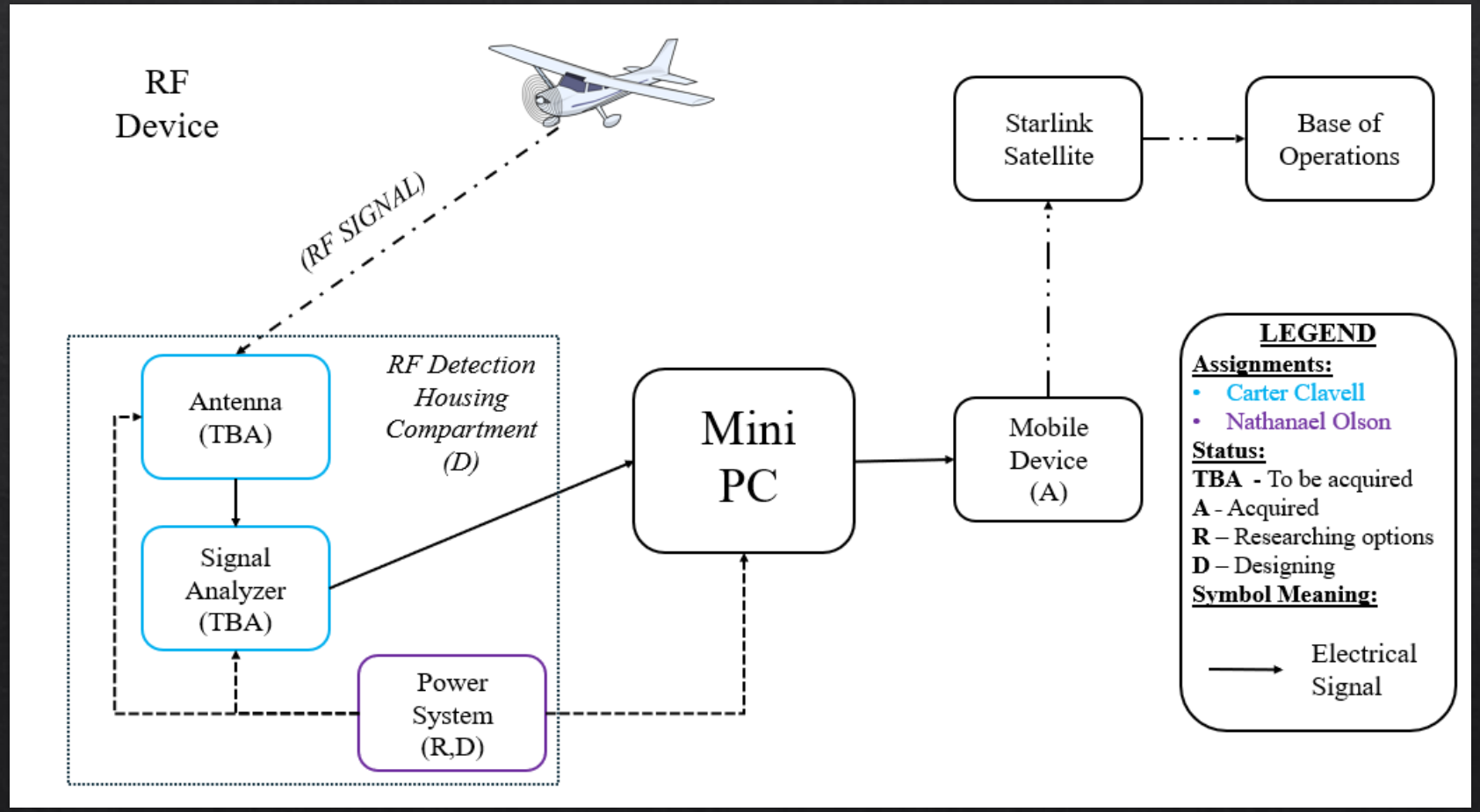
Administrative Content

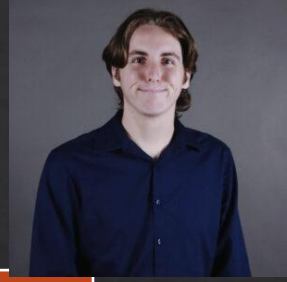
- Budget
- Work distribution
- Progress and plan for completion
- With more allotted time and money what is possible? (Mainly PSE but coud be cool to look to the future)

Budget

Current Hardware	Price	Current Software	Future Hardware	Price
Spectrum Analyzer	$4690.00		Power Supply/ Solar	$449.00
Starlink Terminal	$450.00	$50.00 / month	Raspi 5	$96.89
Aventas Antenna x2	$920.00		2-way Power Divider	$279.00
Android Phone	$800.00	$75.00 / month	Aarona Antenna	$1146.96
Intel NUC	$750.00			
Portable PSU	$130.00			
			Misc. Cables / Motors etc.	$150.00

Work Distribution

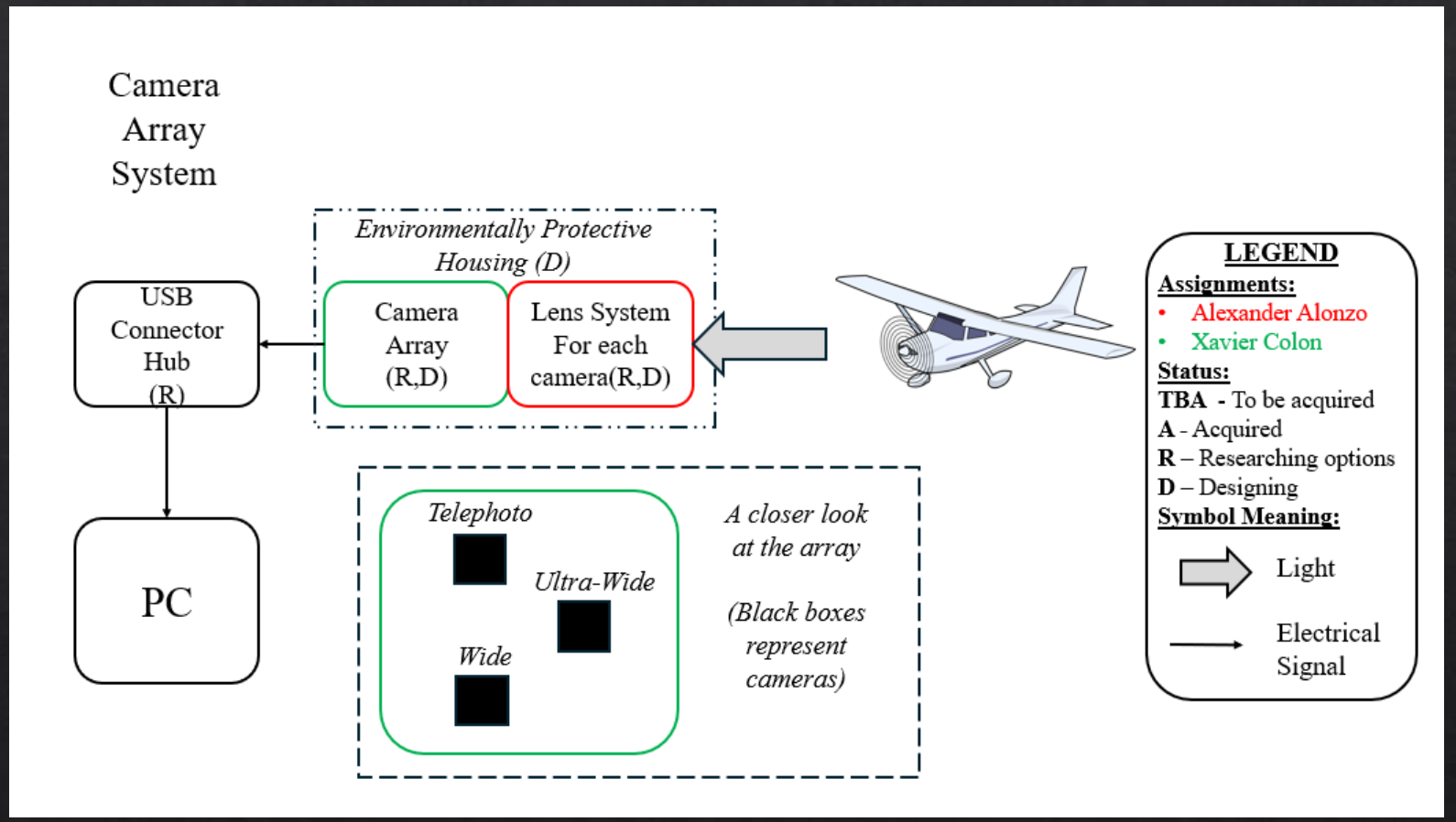




Budget

Component(quantity)	Cost	Vendor	Part Number
Plano-Convex Lens f=125mm(1)	$23.40	Thor Labs	LA 1986
Plano-Convex Lens f=175mm(1)	$22.61	Thor Labs	LA 1229
Plano-Convex Lens f=250mm(1)	$22.14	Thor Labs	LA 1461
Plano-Concave Lens f=-25mm(1)	$32.75	Edmund Optics	#45-030
Plano-Concave Lens f=-35mm(1)	$32.75	Edmund Optics	#48-680
Plano-Concave Lens f=-50mm(1)	$32.75	Edmund Optics	#45-028
Arducam Global Shutter Camera(3)	$50	Amazon	OV9281
Pluggable USB Hub(1)	$40	Amazon	N/A

Work Distribution



Progress and Plan for Completion

Achieved

- 1 mile Radio Detection
- Proof of aircraft detection
- Test setup and Procedure
- Web based server for data
- SDK Implementation of basic algorithm

Not yet Achieved

- Full range and accuracy results
- Implementation of advanced algorithm
- Full web app
- Autonomous Aircraft detection
- Optimized power use

Plan of Action

- More range testing
- Software Development time
- Testing at small quiet airports
- Data collection and labeling

Progress and Plan for Completion

Achieved

- 3 lens designs with 5x magnification with slight differences in field of view
- First iteration of lens tube design

Not yet Achieved

- Lens tube for all three lens designs
- Final arrangement/setup for system

Plan of Action

- 3D printed lens tube testing and improvement
- Test and try different forms of super resolution techniques and choose the best one for our case
- Test, Test, & Test!

Thank You!