Laser Arcade Machine

Design Document

SDMAY22-24

Client

Joseph Kenkel

Advisor

Dr. Neihart

Team Members

Joseph Kenkel

Ashley Robertson

Jonah Stoffer

Mark Kavars

Tyler Beveridge

Morgan Luecht

Zack Larson

Executive Summary

Development Standards & Practices Used

(ANSI/ANS 10.3-1995 Standard for Documentation of Computer Software);(ISO/IEC/IEEE 26514)

IEEE 2030.2.1-2019 - IEEE Guide for Design, Operation, and Maintenance of Battery Energy Storage Systems, both Stationary and Mobile, and Applications Integrated with Electric Power Systems

Summary of Requirements

- Backend server with database
- Multi-platform app development framework
- Blaster
    - Batteries
    - IR emitter
    - LED visuals
- Target
    - IR receiver
    - LED visuals

Applicable Courses from Iowa State University Curriculum

- CPR E 288: Embedded Systems I: Introduction
- CPR E 388: Embedded Systems II: Mobile Platforms
- E E 201: Electric Circuits
- E E 230: Electronic Circuits and Systems
- E E 285: Problem Solving Methods and Tools for Electrical Engineering
- E E 321: Communication Systems I
- E E 333: Electronic Systems Design
- S E 319: Construction of User Interfaces

New Skills/Knowledge acquired that was not taught in courses

- IR Protocol for sending and receiving data.
- Reading Datasheets of components
    - Deciphering Graphs
- Calculating Steradian and power loss with time
- Proper battery management

Table of Contents

1. The Team

1.1 Team Members:

Electrical Engineering

Joseph Kenkel
Ashley Robertson
Jonah Stoffer
Marcus Kavars

Software Engineering

Tyler Beveridge
Morgan Luecht
Zack Larson

1.2 Required Skill Sets:

- PCB Design
    - At a minimum every target and shooter is going to need a Printed Circuit Board (PCB) to connect all of the hardware involved for the individual topics. On top of this, there will likely need to be a pcb
- Wireless Communication
    - Wireless communication will be important for our hardware to interact with each other from greater distances
- Sensor Signal Manipulation
    - We must be able to take the information gathered from our signal and get it to a place that our app can receive and process the information.
- Front End development skills
    - Use known languages to develop phone/ web applications
- Backend Development Skills
    - Develop app that is able to pull data from a piece of hardware to communicate scores to players
    - Store scoring data in database

1.3 Skill Sets Covered by Team:

PCB Design
- Jonah Stoffer, Ashley Robertson

Wireless Communication
- Joseph Kenkel

Microcontroller
- Mark

Front end Development
- Morgan

Back end Development
- Zack

Stack Development
- Tyler

1.4 Project Management:

Scrum and other principles within Agile methodologies to produce an effective and efficient project timeline.

1.5 Initial Project Management Roles:

Team Leader: Joe Kenkel
Laser Generation Lead / General Hardware Lead: Jonah Stoffer
Backend Development Lead: Zack Larson

2 Introduction

2.1 Problem Statement

Laser arcades are entertaining to a wide range of people and demographics. Currently if someone wishes to shoot lasers at targets they need to go to a specific location that hosts that sort of entertainment. We intend to develop a mock system that will demonstrate the possibilities of a portable laser arcade machine.

Ideally the hosts of this portable laser arcade would be able to set targets around a room, turn on the system, and pass out laser blasters. The users would utilize an app on a tablet that provides a UI for the gamemode, stats, and status of the current game.

2.2 Requirements & Constraints

Requirements

Software
- The backend should be hosted on a server of some type
    - Capability to connect to the front end app
    - Capability to connect to the game system itself
- The database should hold key player stats and info
    - Capability to connect to the backend in order transfer the player’s data to

    - the front end to display the players stats to them
    - Capability to automatically update and refresh player's stats
    - Secure and reliable database that we can only access
- A multi-platform app development framework
    - Capability to compile to different operating systems
    - Work on android tablets that will go with the system

Hardware

- Shooter
    - Power
        - Lithium Ion Batteries
            - Rechargable
            - Needs protection Circuitry
    - Emitter
        - IR
    - Visuals
        - shots/ammo left
        - color denote player
        - Spring loaded chamber to reload
        - Denote when fired
- Targets
    - Targets
        - 2-4 targets
            - To be placed 10-20 feet away from shooter
        - Varying in size
            - Area of 16 cm^2
        - Receiver IR
            - Identify each shooter
        - Visuals
            - LED denote
                - When to shoot
                - When hit
                - Which shooter hit it

Constraints

- Budget
    - $1000 - prototyping
    - $200 - Final Product
- Time
    - 10 weeks of design and planning
    - 15 weeks of development

    - Request and receive specific parts for the project in a timely manner
- Scope
    - Mock up of the system
        - Future development could turn this into a marketable product
        - The entire system including the laser blaster, targets, and controller should be extremely portable
            - Plan on having a case to store the system for easy transport
- Risk
    - Two sections of the team will be working on substantially different parts of the project (EE vs SE). Connecting the two main parts is probably the highest risk point.

2.3 Engineering Standards

(ANSI/ANS 10.3-1995 Standard for Documentation of Computer Software);(ISO/IEC/IEEE 26514)

IEEE 2030.2.1-2019 - IEEE Guide for Design, Operation, and Maintenance of Battery Energy Storage Systems, both Stationary and Mobile, and Applications Integrated with Electric Power Systems

2.4 Intended Users and Uses

- Mock project to demonstrate capability of this sort of system
- Intended use is to determine interest and marketability
- Find potential investors or buyers

3. Project Plan

3.1 Project Management / Tracking Procedures

Scrum Agile approach

- Having a set amount of work to complete each week will make it easier to track progress

Software code tracking

- Gitlab

Progress tracking

- Trello

Overall

- Discord server

- WhenToMeet

3.2 Task Decomposition

Software

- Frontend
    - Design application and develop easy to use UI
- Develop android app to display game stats for players and show past history of games played in the past
- Backend
    - Develop database schema for stats accumulated
    - Create database using the schema developed
    - Develop local api on Raspberry PI
- Connect frontend and backend of application
- Connect full application with Raspberry pi/hardware side

Hardware

- Find appropriate emitter and receiver
- Decide on a microcontroller to be used for this project
- Test components for functionality
- Determine Shooter specifications
    - Design PCB for the shooter
    - Distinguish between different shooters
        - Specing out Emitters
        - Figure out PWM signals for each player
- Determine Target specifications
    - Design PCB for the target
    - Receives and distinguishes between players' emitted signals
- Design and print shells for shooter and target
- Develop connection between receptor and controller

3.3 Project Proposed Milestones, Metrics, and Evaluation Criteria

Milestones

Software

- Boilerplate app compiled and ran on tablet
- Database running on pi

- Api running on pi
- Frontend and backend connection is successful
- Fully functional App works with test data
- App connect to api on pi

Hardware

- Schematics for the target and shooter are finished
- Layout for the target and shooter PCBs have been ordered
- Signal received by the receptor once hit.
- Shooter differentiated by receptor
- Central computer acknowledged that a target was hit
- Target receives information from the central computer to light up.
- Database altered when receptor hit

Metrics

Software

- Number of Git commits by each collaborator
- Number of Trello tasks completed
- Milestones reached
- Test coverage

Hardware

- Distance that the target identifies the shooter
- PCBs arriving 8 weeks before the end of class
    - They should be ordered four weeks before that
- Computers can tell which target was hit and by whom.
- Components are wireless
- Shells printed

Evaluation Criteria

Software

- Results of using application features with test data is successful
- # of bugs found in code/ # of refactored commits to Git
- Peer and Faculty Advisor review of UI

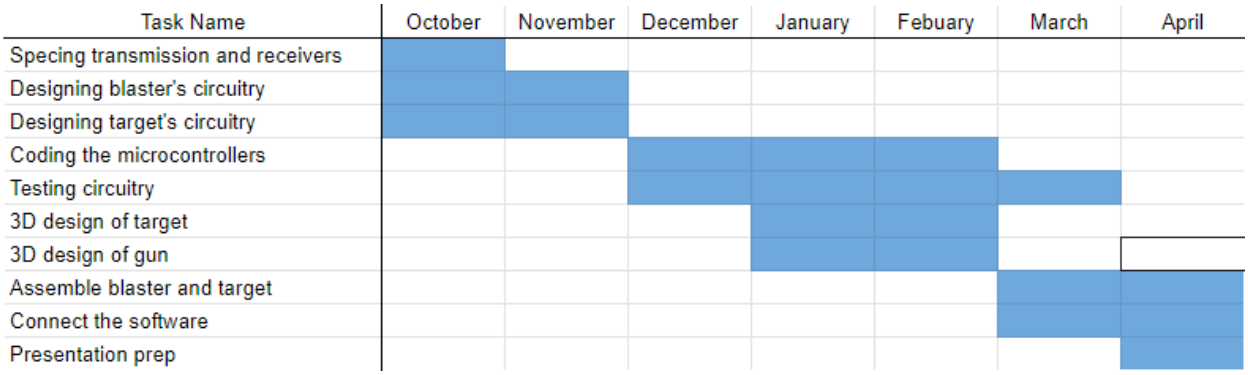
Hardware

- Finished pcb for the target should be under 16 in^2

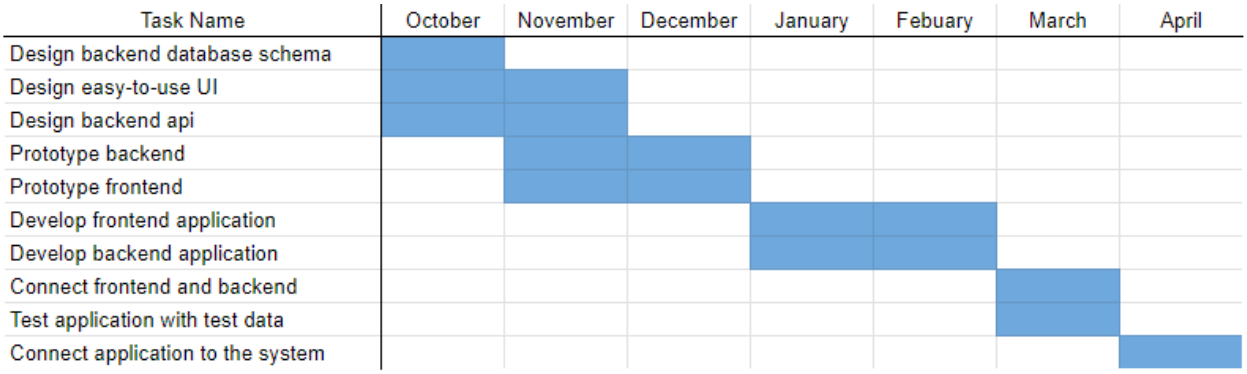
- The target will have an 8 in tolerance from the center to register a hit.
- PCB schematic and layout are peer reviewed

3.4 Project Timeline / Schedule

Hardware



Software



3.5 Risks and Risk Management / Mitigation

- Disconnect between the hardware and software

Software

- Running into issues connecting the frontend and backend of application
- Running into issues connecting the application to the raspberry pi and hardware system
- Login data security
- Management risks (no real leader established)
- Schedule Risk/Technical Risk(Never worked with some of the things)

Hardware

- Difficulty finding parts or parts running out of stock when we try to order them.
- Possible issues when we connect system to interface with the software and app
- Possible issues when we begin to actually use the laser
- Lithium Batteries exploding

3.6 Personnel Effort Requirements

Software

- Looking at the gantt chart we estimated that each software member would work an average of 5 hours per week. Based on the duration of each task we calculated the amount of time each one would take to complete.

Design backend database schema	40 hours
Design easy-to-use UI	40 hours
Design backend api	40 hours
Prototype Frontend	45 hours
Prototype Backend	45 hours
Develop Front end application	50 hours
Develop Backend application	50 hours
Connect front and backend	15 hours
Test application with test data	20 hours
Connect full application to raspberry pi/ hardware	30 hours

Hardware

Specing transmission and receiver	5 hours
Designing Shooter's circuitry	50 hours
Designing Target's Circuitry	50 hours
Coding the microcontrollers	50 hour
Testing Circuitry	50 hours
3D design of Target	20 hours
3D design of Gun	20 hours
Assemble Gun and Target	10 hours
Connect to Software	105 hour (15 hours for the 7 of us)
Presentation Prep	15 hours
Documentation	40 hours
Weekly Reports	20 hours

3.7 Other Resource Requirements

- Raspberry pi
- Android tablet
- 2 Laser emitters
- 2-4 Laser receptors
- Lenses?
- 4 Transmitting and receiving board
    - Bluetooth board
- 3D printer
    - Printer Filament
- 4 Microcontrollers

4. Design

4.1 Design Context

4.1.1 Broader Context

The design problem that we are tackling, is in a world where laser arcades are stationary at sparse locales. We want this design to assist college students as well as family households in their efforts to entertain themselves and others in times of boredom. College students would find a decent price point product that would be able to entertain large groups of people at once. Families would be able to entertain children and guests without requiring significant setup. This project would fill their need for easy and simple entertainment.

Below are relevant considerations to this project in defined areas:

Area	Description	Examples
Public health, safety, and welfare	This project does not much affect this area, however part of the decision to use IR light was to remove the danger of lasers or physical objects flying through the area. This product would leave the user as they started in terms of health and safety.	Our IR emitter will fall below the IEC-62471 standard for light safety.
Global, cultural, and social	This project reflects the values of “toy like” consumer goods in the U.S. The “blasters” will look distinctly like a toy rather than a firearm, and the targets are small and can be attached to objects at the user’s discretion	Targets could be attached to children friendly objects or to more realistic animal statues. The gun will look akin to a nerf gun with bright colors to appeal to the maximum audience.
Environmental	There will be 3d printing involved using plastics that would potentially end up in trash and last a long time. Additionally microcontrollers and a microcomputer require tech parts that may be costly or hard to find.	Say this came with the raspberry pi to control it. Then once the laser arcade aspect to this product is worn, broken, or finished the PI could be utilized further.

Economic	This will have minimal effect on anything other than a decent price to the consumer.	Similar price to typical higher end games like lawn darts, badminton, or cornhole.

4.1.2 User Needs

A household (consisting of parents and kids / group of friends) needs to be able to set up their own laser arcade without an internet requirement to entertain kids or a party.

College students need to be able to bring an IR blaster and targets to dorm rooms or common areas to entertain themselves at a low cost.

4.1.3 Prior Work/Solutions

The main inspiration for this project came from a laser arcade solution found at Bass Pro shops. At these locations targets are placed in a “hunting” environment with targets like animals, cabin parts, and misc small items placed around. Each player has a fake hunting rifle that probably shoots IR light. When shooting these targets effects occur on hit in the environment which add to the enjoyment of the arcade.

A product that could be considered similar are the video game variety of shooting arcades. One that specifically has some overlap is the switch party game with a speed drawing mini game. In that game players hold the controller in a specific “holstered” direction and on the start sound quickly point the controller up and shoot.

Pros of our product

- Our product will be easily portable unlike Bass Pro Shop’s larger stationary arcade.
- Our product will be more tactile with a physical laser shooting gun and physical target that is better than just shooting targets on a screen as a mini game.

Cons of our product

- The advanced effects in the environment that Bass Pro Shop has is much better than what we plan to do.
- Our product will not be set up to shoot towards other players like the switch mini game or laser tag games in general.
- You can not see where you hit.

4.1.4 Technical Complexity

This project is of sufficient technical complexity mainly due to the components required and the connections needed between those components. Below is the list of components of this project:

1. IR emitter (Blaster)
2. IR receiver (Target)
3. Target microcontroller
4. Blaster microcontroller
5. Mobile android application
6. Raspberry PI backend server
7. Aesthetic Cases for the blaster and targets (3d printing)

Connections required

1. The IR receiver connected to the microcontroller and decoded
2. The microcontrollers bluetooth connected to the Raspberry PI
3. Mobile application wifi connected to the Raspberry PI
4. IR emitter connected to the IR receiver through IR light

The IR requirements for this project match the current solutions like Bass Pro Shop. Connecting an app through wifi and microcontrollers to bluetooth exceeds solutions like Bass Pro Shop or similar video game solutions.

4.2 Design Exploration

4.2.1 Design Decisions

One design decision that we made was to use IR emitters and receivers to handle the shooting of the targets. On these we need to determine and obtain microcontrollers that would read Pulse Wave Modulated signals from the blaster and send those to the central controller.

A second design decision we made was utilizing a Raspberry PI for the central control of the game system as well as housing the backend for the system and app. The PI is a powerful enough mini computer to handle the computing power of both requirements and has built in wifi routing capabilities and bluetooth connectivity.

A third design decision we made was to use React Native for the native application. React Native is a multiplatform javascript framework for developing native apps and provides HTML like UI development.

A fourth design decision we have yet to make is the exact emitter and receivers to use. The emitter will determine what receivers we can use through its PWM. Additionally, we have to watch out for stock shortages that may require us to use components that are less desirable.

4.2.2 Ideation

When determining the connection method between the blaster and targets we utilized brainstorming to come up with different ideas and build off each other. The options we considered are as follows:

1. Lasers
2. IR light
3. Airsoft
4. BBs
5. Air
6. Bullets

4.2.3 Decision-Making and Trade-Off

We decided that using light would be the easiest for all ages to use and also the easiest to pick up. This also does not have any maintenance cost to keep using. When it came to using IR vs visible light, Neihart advised us about the dangers of blinding people with visible light.

Type	Pros	Cons
Visible light	● Can see where the target hit ● Easy clean up	● Could blind someone
IR light	● Less of a risk of blinding people ● Easier to tell the difference between players using different PWM signals	● Wider beamwidth ● Not visible so you can’t see when you missed ● ammo/shots are essentially built into the shooter
Airsoft	● Easier to detect a hit	● Need to buy ammo

		• Harder to clean up
BB's	• Easy to measure • Easy to get a hold up	• Upkeep cost • More dangerous for little kids • Harder to clean up
Air/ dart/ Nerf	• Safe	• Have to clean up
Bullets	• Reach a long distance. • Very adrenaline pumping to use	• Dangerous

4.3 Proposed Design

4.3.1 Design Visual and Description

Blaster

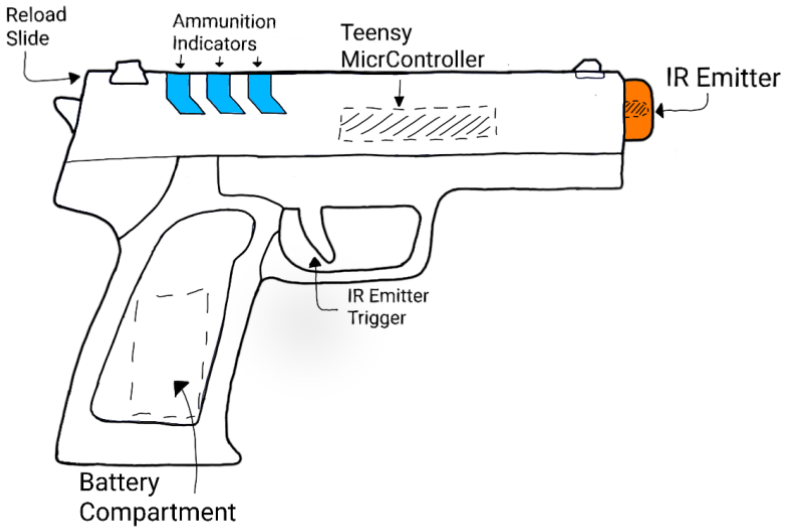


Figure 1: Blaster Visual

At the heart of the shooter's design, it is essentially a battery powered IR Emitter. For the outer visual aspects of the shooter, it will appear as a toy-like pistol with an orange tip to indicate that the shooter is not a real weapon. It will also have a set of LEDs on each shooter to indicate both player color and shots left. It will also have a retractable slide and movable trigger. As for the inner design of the shooter, it will have a removable

battery compartment. As for communications with other systems, it will communicate with the target via IR and with the raspberry pi via bluetooth.

Target

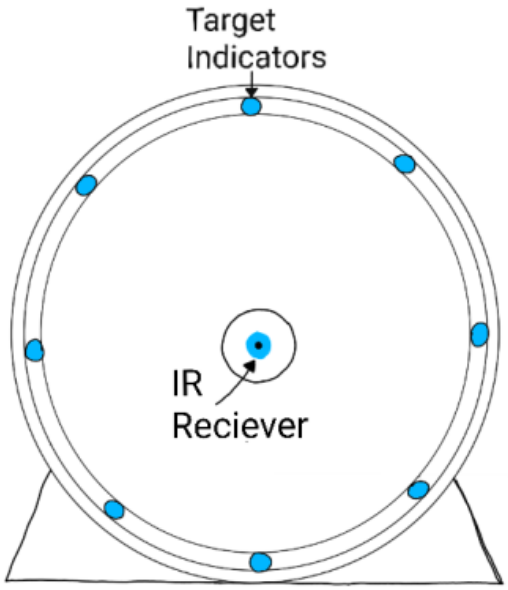


Figure 2: Target Visual

At the heart of the target, it is an IR Receiver. The target will each range between 4 to 8 inches in diameter. The rest of the target shape however can freely vary outside of that as long as it can fit the circuitry and battery needed for it to properly function. The targets will be brightly colored to allow for each player to easily identify the targets. There will also be RGB LEDs on the target to notify the players which of them have scored. There will also be stands and mounting holes to allow the targets to be placed in various locations

4.3.2 Functionality

Blaster:

In order to power the entire IR blaster, a lithium ion battery will be used. The exact size of the battery will be later determined after a power analysis of the shooter is completed. There will be a battery charging circuit to properly charge the circuit in a safe manner. This will then power a Teensy LC microcontroller which controls the rest of the electrical components within the device. When the trigger is pulled, it will hit a limit switch which

signals the teensy to send a PWM wave to the IR Emitter that is unique to each blaster. Immediately after this happens, this will then turn off one of the ammunition LEDs that is on the shooter. When all of the ammunition LEDs are turned off, pulling the trigger will not activate the IR Emitter. When the user pulls back the slide, it will then hit a limit switch that signals to the Teensy LC to turn on all of the ammunition LEDs. For any data that the shooter needs to either receive or transmit, it will do this through the bluetooth module that is connected via the Teensy LC module.

Target:

In order to power the entire IR blaster, a lithium ion battery will be used. The exact size of the battery will be later determined after a power analysis of the shooter is completed. There will be a battery charging circuit to properly charge the circuit in a safe manner. This will then power a Teensy LC microcontroller which controls the rest of the electrical components within the device. The target has RGB leds on the outside of the case that displays a variety of information to the user. When the target is ready to be shot by the user, the LEDs will shine white. Once the receiver receives a PWM signal from either blaster, the Teensy LC will detect which player shot the target and change the LEDs the color of the player who hit the target first. For any data that the shooter needs to either receive or transmit, it will do this through the bluetooth module that is connected via the Teensy LC module.

4.3.3 Areas of Concern and Development

Our biggest area for concern is the process of making sure all aspects of our project can effectively communicate with one another smoothly. I don’t believe we will have much of a problem creating each part of the project but actually verifying that all forms of communication between parts are successful will be the biggest challenge. Our immediate plans for a solution to this, is to start creating the main components of the project early on so we will have enough time to debug the issues that we will undoubtedly face when combining all of the aspects of the project together. Since we are still not at this step yet in our project, we don’t have any questions of concern at this point.

4.4 Technology Considerations

The IR beams are less precise than visible lasers. By choosing IR, you can not see where the shot landed and adjust your aim accordingly. Without the lazer, you can not shoot as far and the beamwidth is much larger causing the receiver to falsely trigger. On the other hand, we choose the IR because it is way less likely to blinde someone. In

order to help deal with the issues caused by the large beamwidth, we chose an emitter with a low beam angle to make the range of the beam as small as possible.

We decided to wireless communicate from one board to another. This adds a layer of complexity over wired communication but also more freedom on where to put the target.

4.5 Design Analysis

Based on what we have tested so far, the design seems feasible. We have not gotten to the implementation stage but instead still in the testing phase. We have tested and proven that each step will work and work together but they have not all been put together.

An example of this is that we can prove that the teensy can send a signal through the ir emitter which is then picked up by the ir receiver and read by the teensy. Apart from that we have sent a signal with the teensy through the bluetooth to a phone. We have not yet gone the whole way. To go on top of that, we have a lot more auxiliary easier stuff to add such as a button to fire and lights to add feedback. Overall I think we are on the right track and can streamline the rest of the design now that the hardest part is done.

4.6 Design Plan

Our design plan is to have two fully functional shooters and four functioning targets. These will be able to be placed around a normal sized living area (12 feet x 12 feet) in order to showcase the ability of the system to communicate up to 15 feet away. The app will be displayed on a tablet to show off the player interface that we have created.

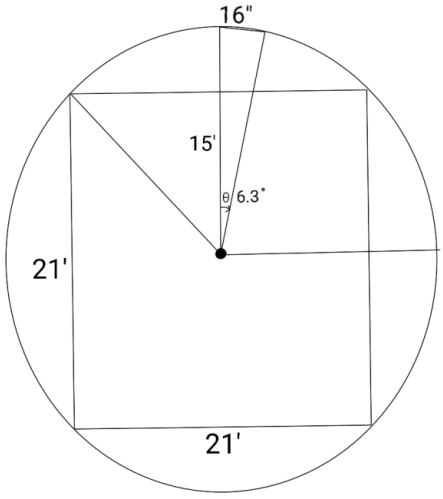


Figure 3: Expected Range of the System Compared to the Maximum Room Size

5 Testing

5.1 Unit Testing

Tablet and Game Software

Unit testing for the tablet application will utilize the React Native default testing environment Jest. Using Jest will allow the screens, components, and functions to be checked for correctness with multiple different inputs. These units will take in test values for props that make sure what is meant to be in the final render values is as expected.

The backend database and server will be tested using the typical Java testing library JUnit. We will have default database values for testing that will be inserted so we can test the backend functions that deal with altering the database tables. The controllers and the individual functions will utilize JUnit to ensure proper inputs output the expected values.

Blaster and Target

The PWM output of the controller needs to be distinct enough to give it its own ID. In order to test that this works, we will hook the output up to an oscilloscope. This allows us to view the signals and make sure that they are working properly

5.2 Interface Testing

Interface testing between the frontend and backend will be handled manually through a locally running server and a locally emulated application. Additionally, testing will occur manually between the raspberry pi server and the physical tablet to make sure connections are made.

Another test is checking to make sure that the receiver can pick up the transmitter at different angles and distances. In order to test this, before installing the IR LED and Receiver, we are going to put them in so close to a final environment without having to have all the parts built yet. We will then test it at 0, 20,35,45,60,75,90 degrees elevation with azimuth being constant and see at what angle it no longer receives it. We will also use these angles at each distance moving back in 10 feet measurements until the receiver no longer picks it up at 0 degrees elevation. To do this, we will need a tape measure, portable power source, a room large enough to expand, and led or some way to check if the receiver is actually picking it up.

We will also need to check the interface between the Pi and the microcontrollers. We will send basic communication between the two devices in order to check that they are connected

5.3 Integration Testing

The critical integration paths that need to be tested are the connections between the targets/blasters to the raspberry pi server, the raspberry pi to the targets/blaster, and the tablet to the raspberry pi. The testing to ensure connectivity will be done by checking that the bluetooth/wifi connections are made, and potentially adding startup sequences that indicate connectivity between the devices.

5.4 System Testing

One important system test is checking that the Pi receives the signal once you transmit the IR signal from the transmitter. This would involve sending the signal in a place that the receiver can pick it up, and then converting that message into bluetooth to allow the Pi to recognize the hit.

Another systems level test is to test the different game modes. We would have the game start, signal to the target to turn on the LED while also starting a timer. Then once the lit up target has been hit, stop the timer and deliver points accordingly. We must first make sure that they all work individually, once that works, making sure that the interfaces work, and finally if this broad method works.

5.5 Regression Testing

To ensure that none of the old functionality is broken when adding new features we would need to retest that old functionality is still working. Among the critical features we must ensure the constant functionality of the communication between the target to shooter and the target/shooter to the raspberry pi. As per the requirements we will need to test for the target recognizing that it has been hit and verifying the player that hit it.

5.6 Acceptance Testing

We will consistently refer to our team’s design diagrams, sketches, and other visualizations we have drawn up and agreed upon to make sure that those requirements are being met. We believe in the functional and non-functional requirements we have decided on so making sure and testing that each aspect of our project aligns with those requirements are going to be essential. We will demonstrate this by incrementally testing each aspect of the project before and after every part of the

project becomes connected with another part of the project. Our client is actually a member of the team so they will be heavily involved in this part of testing because he, like the rest of the team, has a detailed idea of how the project and system should look and interact with each level of the system. We will also consult with our faculty advisor as another form of acceptance testing to ensure that the agreed upon requirements are being met.

5.7 Results

We want clear proof of communication. We must be able to control the input signals and see a clear linear output signal. We will compare them to the requirement to make sure that after each test, we can check off another part of the list. We will go through many scenarios for each requirement to ensure they are working fully to what we expect. This will allow us to be confident that our design is as intended and useful.

6 Implementation

We have the parts working individually, and to implement this we will need to put everything together. To do this, we must finalize the schematic and turn it into a PCB. We must also build the shooter and the target. The target is going to be 3D printed to hold the PCB and components. The shooter will either be 3D printed or repurposed from a toy.

7 Professionalism

7.1 Areas of Responsibility

Pick one of IEEE, ACM, or SE code of ethics. Add a column to Table 1 from the paper corresponding to the society-specific code of ethics selected above. State how it addresses each of the areas of seven professional responsibilities in the table. Briefly describe each entry added to the table in your own words. How does the IEEE, ACM, or SE code of ethics differ from the NSPE version for each area?
Using IEEE codes of ethics

Area of Responsibility	Definition	NSPE Canon	Our Definition
Work Competence	Perform work of high quality, integrity, timeliness,	Perform services only in areas of their competence; Avoid deceptive acts.	Do good work, only take a job if you're qualified, and deliver it in a timely manner.

	and professional competence.		
Financial Responsibility	Deliver products and services of realizable value and at reasonable costs.	Act for each employer or client as faithful agents or trustees.	Do not cheat anyone out of their money, or products.
Communication Honesty	Report work truthfully, without deception, and understandable to stakeholders.	Issue public statements only in an objective and truthful manner; Avoid deceptive acts.	Do not lie or withhold information.
Health, Safety, Well-Being	Minimize risks to safety, health, and well-being of stakeholders.	Hold paramount the safety, health, and welfare of the public.	Do not physically or emotionally harm anyone,
Property Ownership	Respect property, ideas, and information of clients and others.	Act for each employer or client as faithful agents or trustees.	Do not take others' property or ideas. Do not plagiarize.
Sustainability	Protect environment and natural resources locally and globally.		Do not needlessly hurt the environment.
Social Responsibility	Produce products and services that benefit society and communities.	Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor,	Make a product that possibly impacts the world around you. This involves making something that is ethical and useful to society.

		reputation, and usefulness of the profession.	

Area of Responsibility	Affected areas	How they differ
Work Competence	Maintain competent work while disclosing important information that could affect the project in any way. Avoid conflicts and withholding information. Help coworkers do the same.	The NSPE code requests that the professional should perform services specifically within its own competency area. The IEEE code mainly says to maintain a certain level of technical competence.
Financial Responsibility	Being honest when disclosing information about cost.. Don't make unfulfillable claims	The NSPE code of ethics goes more into detail about accepting compensation and how the engineer should not accept payments for the same project from more than one party. The IEEE code just states to avoid conflicts of interest.
Communication Honesty	Uphold high levels of honesty and integrity when communicating with stakeholders and colleagues. Don't lie about information that could affect the project or safety of others and the environment.	The NSPE code of ethics goes more in depth on how the engineer should communicate objectively. They both say that deceptive cts and lying is unethical and should be avoided.
Health, Safety, Well-Being	Don't harm others in any capacity. Report information that could affect public safety.	IEEE talks about the safety of the client/ stakeholders. This means that you should only watch out for the people giving you money while NSPE talks about the public and how you should protect the many.
Property Ownership	The product is your property and you should accept responsibility for every decision that is made about it. You can improve this product by being open about it and accepting criticism, and to	IEEE talks more about ideas and not taking others' property while NSPE talks about working as a team to build a better result by taking pride in your work.

	remember that this project succeeds and fails as a team so you must assist your colleagues.	
Sustainability	By accepting the responsibility for the environment, we are taking responsibility for making it sustainable.	IEEE is the only one with a definition. We can not talk about their differences when we only have one definition.
Social Responsibility	You must be responsible by divulging conflict of interests, keep it fair by refusing bribery, communicate our skills and not lie about them, not discriminate, take others property as our own and finally help your coworkers grow.	The NSPE code of ethics calls for the engineer to report others that may be violating ethics or acting in an unlawful/illegal manner. The NSPE code of ethics in general goes more indepths on the responsibilities of an engineer to handle confidential information and how they should act in lawful ways.

7.2 Project Specific Professional Responsibility Areas

Area of Responsibility	Applied	How is it used	Team performance
Work Competence	Yes	We are aiming to deliver a high quality product in a timely manner. This means that the product will not be late and finished on time. We do not steal others ideas and maintain high integrity.	High
Financial Responsibility	Yes	We look at the cost of two different objects and include cost into our factor on what to buy. We do not just instantly buy the most expensive part, but we also splurge in some areas for easier convenience to build at a higher cost.	Medium
Communication Honesty	Yes	We accurately inform the team on what we are working on and when we need help. We also accurately inform Dr. Neihart with what step we are on and even if we are behind. This honesty even when behind is key.	High
Health, Safety, Well-Being	Yes	We did not go with the better performance laser, but instead chose IR because it was safer. In building our design, we took the safer route every time.	High
Property Ownership	Yes	Our ideas about making this project work are our own. We do not find the solution online and copy it word for word. We are the creator and designer of this project and do not take from others.	High
Sustainability	Yes	Since our ammo does not require non renewable foam. We are not using recycled plastic or recycled parts for the most part so that hurts our sustainability.	Medium
Social Responsibility	Yes	This product will supply kids with fun without hurting the environment. Most other shooters fire a projectile that if not picked up can negatively affect the environment. An example of this is a nerf gun which is renowned for losing their foam ammunition.	High

7.3 Most Applicable Professional Responsibility Area

Identify one area of professional responsibility that is both important to your project, and for which your team has demonstrated a moderate or high level of proficiency in the context of your project. Briefly describe what this responsibility means to your project, the ways in which your team has demonstrated the responsibility in the project, and specific impacts to the project that you have observed

We would say that the area of responsibility that our group has demonstrated the most proficiency in as well as being very important to our project is Health, Safety, and Well-Being. This is because there are some safety concerns when dealing with lasers in any capacity, and because our project (Laser Arcade Machine) revolves around a some sort of laser we would naturally need to take this under consideration. We chose to use an infrared laser instead of a visible one. This minimizes certain risks and concerns that would arise when implementing a laser in a product meant for a wide age range. We no longer fear blinding the users or passers by. This has several impacts on our project. The infrared laser has a wider beam than the alternatives so the device will be less accurate when deciding what is a hit and what isn't. We have also noticed that since the IR laser is not visible there will be no indication of how far the user missed the target. We also believe that this may make the actual testing of the product more difficult and finally quality lower in the future but it will keep the user and bystanders safer.

8 Closing Material

8.1 Discussion

For the application, our designs for all of the screens that will be used within the application meet all of our requirements necessary to deliver the final product successfully. Our frameworks that we have selected will enable us to succeed in implementing an easy-to-use user interface for the users which is the most pivotal requirement of the application.

Our transmitting distance requirement was that the emitter shall be able to send a complete signal packet and the receiver shall properly receive this information from 15 feet apart. Figure ?? shows the signal sent from the infrared emitter (the yellow trace) and the signal received by the infrared receiver (the green trace) from about 7 feet apart. We have been able to consistently receive the complete emitted signal from 15 feet away with a beam width of about 6.3 degrees.

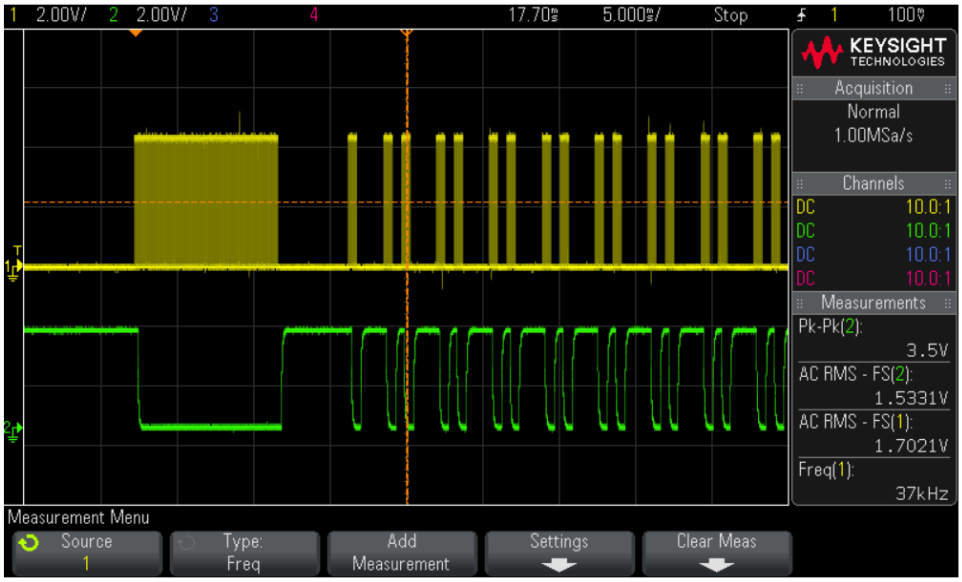


Figure 4: Transmitted (yellow) and Received (green) Signals

For our target and shooter to communicate with the central unit we are using bluetooth. We have been able to both transmit and receive information via a bluetooth module and mobile.

8.2 Conclusion

Currently, our team has created the framework for an app and started on the UI design. We have determined all frameworks and dependencies of the app, and tested communication between the Pi and app. We began developing a prototype for the gun and targets, and have begun integrating the hardware with the software. Our goal in the end is to have a fully working IR gun, complete with working mechanical and electrical components and visual feedback in the form of LEDs, to have working wireless targets that can receive signals from the guns, determine which gun hit it, and send that information to a microcomputer. Finally, our last goal is for the microcomputer to be able to process that information and update the app with it.

The best way to complete these goals is to continue prototyping and testing, and come up with a final design for the targets and guns. We can then take those designs and implement them on a PCB. The biggest problem the hardware team encountered was the part shortage. Parts were in short supply in online stores, and many of the ones left either had a long wait list or were very expensive. We ordered the best parts at our disposal given the limited choices for our project. In the future, our best option was to decide on parts sooner, as one of the reasons we had less options was because we

waited a bit longer than we should have to order the components we needed for prototyping.

8.3 Appendices

8.3.1 Team Contract

Team Name: sdmay22-24
Team Members:

1) Marcus Kavars
2) Morgan Luecht
3) Zack Larson
4) Ashley Robertson
5) Tyler Beveridge
6) Joseph Kenkel
7) Jonah Stoffer

Team Procedures

1. Day, time, and location (face-to-face or virtual) for regular team meetings:
    a. The group will have bi-weekly meetings that the entire team is expected to attend. These meetings will be held every other Monday at 9pm. The meetings will be held virtually via a discord server which every member will be a part of. If the meeting is expected to start early or end late for any reason, all team members should be given at least a few days heads up to make them aware of a schedule change

2. Preferred method of communication updates, reminders, issues, and scheduling (e.g., e-mail, phone, app, face-to-face):
    a. The main form of communication for our team will be via Discord. Every team member is in the discord server at this point along with the Jacob Betsworth (TA) so everybody can get all updates. Major updates should also be posted within the respected channel for the group to see.

    b. Communication with the client (Dr. Neihart) shall be done via email. Any person that the email would pertain to shall be cc'd in the email. For example, software questions should have all software members, hardware should have all hardware members, and general members will contain everyone. If for any reason there is any issues with any email correspondence, the TA will also be cc'd to be made aware of the situation

3. Decision-making policy (e.g., consensus, majority vote):
    a. When coming to a decision everybody will be able to make a case for how they want to approach a decision. Once everybody's ideas have been

shared and debated amongst the group, a vote will be held. The idea with the majority votes will win

4. Procedures for record keeping (i.e., who will keep meeting minutes, how will minutes be shared/archived):
    a. All documents will be collected in a shared Google Drive folder that everyone has access to. All meeting notes shall be kept in the respective notes folder/document that shall be updated during every meeting. The meeting date, time, and length shall also be posted in the notes document to record how long meeting times are

Participation Expectations

1. Expected individual attendance, punctuality, and participation at all team meetings:
    a. Each team member is expected to attend all meetings planned, and is responsible for getting information if they have a conflict. Team members will inform others if they will be late or have a conflict. Everyone is expected to participate.

2. Expected level of responsibility for fulfilling team assignments, timelines, and deadlines:
    a. Each team member should contribute and fulfill required work on time. If not, team will discuss and review said actions on how to do better in the future

3. Expected level of communication with other team members:
    a. Each member is expected to communicate any delays in the deadline to all the other members. They should also share any major progress made and major resources used.

4. Expected level of commitment to team decisions and tasks:
    a. Try to split all of the work evenly and give each member a chance to voice their opinion for all team decisions and be okay with not going with their choice if the team votes in the majority of another decision.

Leadership

1. Leadership roles for each team member (e.g., team organization, client interaction, individual component design, testing, etc.):
    a. Joe - Target sensor and wireless communication / Team Organization
    b. Morgan - Frontend development lead

   c. Jonah - Laser Generation Lead / General Hardware Lead
   d. Ashley - RF Lead / Client interaction
   e. Tyler - Full Stack developer
   f. Zack - Backend development lead
   g. Mark - Integrating signals into software

2. Strategies for supporting and guiding the work of all team members:
   a. Team members will ask other members for help if needed on tasks. All members will be able to review work completed and communicate if they feel something needs to be corrected. This will be done in a respectful manner. Since we will communicate our expectations of each task, we will be able to support each other's work.

3. Strategies for recognizing the contributions of all team members:
   a. Talk during the small and large meetings about what has been accomplished so all members know what has been accomplished

Collaboration and Inclusion

1. Describe the skills, expertise, and unique perspectives each team member brings to the team.
   a. Joe - wireless communication and sensor usage.
   b. Tyler - Web development, Javascript, Python
   c. Jonah Stoffer - Hardware design and PCB layout, also some experience with digital signal processing.
   d. Morgan - Software design/front end development, Web/app development
   e. Ashley Robertson - Hardware Design, PCB Layout, Wave Propagation
   f. Zack - Web Development, Data management/handling, backend development
   g. Marcus - Microcontroller programming, hardware design

2. Strategies for encouraging and support contributions and ideas from all team members:
   a. Discord channel devoted to asking questions and for help.

3. Procedures for identifying and resolving collaboration or inclusion issues
   a. Bring up any concerns that one has at the team meetings so we can all work together to discuss and resolve any collaboration and inclusion issues.

Goal-Setting, Planning, and Execution

1. Team goals for this semester:

    a. Create a solid design and plan to follow for the next semester to be able to deliver a mobile laser game.
2. Strategies for planning and assigning individual and team work:
    a. Assigning individual work and team work at group meets. Go over everyones expectations for tasks.
3. Strategies for keeping on task:
    a. Set deadlines
    b. Change deadlines if needed for specific tasks

Consequences for Not Adhering to Team Contract

1. How will you handle infractions of any of the obligations of this team contract?
    a. Bring it up in a team meeting to discuss how these can be avoided in the future

2. What will your team do if the infractions continue?
    a. Reach out to the TA for further guidance on how to best handle to situation

****

a) I participated in formulating the standards, roles, and procedures as stated in this contract.

b) I understand that I am obligated to abide by these terms and conditions.

c) I understand that if I do not abide by these terms and conditions, I will suffer the consequences as stated in this contract.

1) Marcus Kavars	DATE 9/14/21
2) Morgan Luecht	DATE 9/14/21
3) Zack Larson	DATE 9/14/21
4) Ashley Robertson	DATE 9/14/21
5) Tyler Beveridge	DATE 9/14/21
6) Joseph Kenkel	DATE 9/14/21
7) Jonah Stoffer	DATE 9/14/21