UCF Senior Design 1 Divide and Conquer Document

Neon Knights
Group A

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1.0 Project Narrative

Have you ever played laser tag whether it's at a specific place for laser tag or in the back room of an arcade you probably had fun but did you ever think to yourself why couldn't this technology be more advanced or easier to use. You may have thought why does the gun need to be connected via a thick wire or why does the vest feel like I'm getting ready to go scuba diving? In general, most laser tag places have a cheap laser tag system that's not very user-friendly. We decided to try and fix some of the main issues involved with laser tag and add our own spin to it to make it more fun for the users.

1.1 Background and Motivation

Engineering has been around for a very long time. It started with the very basics of building useful things like buildings or even the wheel but as civilization progressed engineering was used for different purposes. The main purpose engineering came about was through warfare as whoever held the newest engineering technology whether it was a bow and arrow, a trebuchet, or even a highly advanced military plane was the most powerful. One invention that revolutionized warfare was the rifle which was used to shoot from a distance without having to get close to the enemy. As engineering progressed into the modern world more and more peaceful things were invented including infrared and laser technology. Eventually, someone mixed the warfare of a rifle with the technology of infrared lasers and sensors to create laser tag. Laser tag has many purposes; it can be used for anything from advanced military training to a toy children use. The background behind laser tag may come partially from warfare roots but no matter what its purpose is for now it's a pretty fun game to play with friends.

When we began thinking of projects we started with the basics of what are the engineering requirements for this project. We knew we needed to include multiple things like a printed circuit board (PCB), a microcontroller (MCU), a power supply, hardware implementation, software implementation, sensors of some sort for Input, and some sort of output. Although these are not all required and many more things may be required these were some of the thoughts we had when thinking of a project to build. With keeping all of these requirements in mind we began to have a very long list of possible projects to build but something felt like it was missing. We kept brainstorming on projects that would fit these engineering descriptions but for some reason, we were indecisive and kept coming up short. That's when we got together as a group and decided we needed to add another requirement: our project should have filtered out the bad projects we were less interested in designing.

In senior design, we are tasked to create a project that has many engineering requirements. One requirement our group added was the project should be considered fun. The requirement to make our project fun was imperative as having a project that the group is interested in promotes more work to be completed. That's where we started thinking and we landed on laser tag because it fits the requirements of the engineering side while also fitting into the fun category. This is a game that involves almost all types of skills and challenges; it requires physical activity, hand-eye coordination, and strategy.

Another reason laser tag is so great is because of its age inclusiveness, social interaction, and competitiveness. These attributes and the skills involved make it the perfect game to play with friends. These reasons make it such a fun game to play which in turn is the reason we believe it will be a fun game to build.

We decided to pursue laser tag for our senior design idea because it fit all the hard requirements set by the professors and it fit the soft requirements we set. Although one of the main soft requirements we set was that the project had to be fun there were many other requirements we set that were imperative for our design. One of these soft requirements we liked in our idea was its changeability of difficulty involving the hard requirements. This means if we are struggling with the project we can keep it very simple by just making a basic laser tag system but if we find the project easy as we do more research we can implement an endless amount of ideas to make the design fit the perfect difficulty. This can give our project unlimited possibilities as we can implement upgrades to the system as we desire to make the game of laser tag more fun for its users. Another requirement we had was its demonstrability as we need a project that is easy to display to whoever is reviewing the project. We also wanted a project with good testability in this design we can test each part and each system as a subsystem before we implement the project altogether. This can help create the project because if we test each subsystem beforehand we won't need to put everything together and hope that nine months of effort will work. With all of the hard and soft requirements being met, laser tag was the perfect balance and our team is extremely motivated to design this project.

1.2 Project Function

Laser tag is a safe real-life shooting game with handheld devices that use infrared light to shoot or more realistically tag their opponent. These handheld devices shoot an infrared laser which is used to essentially tag your opponents that is why it's called laser tag. This concept is incorporated into a fun game that involves using many skills like hand-eye coordination, strategy, and teamwork to tag your opponent and win the game. Now that you know the concepts of the game laser tag you still need to understand how the technology in laser tag works and how we intend to implement it. The main game of laser tag is usually played with two main components: a gun or phasor and a vest or sensor, although often these components are connected via a wire. The gun or as some like to call it a phasor for a more futuristic sci-fi theme is fundamentally a device made to shoot an infrared laser. The vest is essentially a bunch of infrared sensors attached to a vest that is meant to detect the infrared laser from the phasors. In our design, we plan to separate these two components to build a separate gun and vest that will connect but have their functionality.

First, we have the phasor or laser tag gun which will have plenty of components that will function on their own separate from the vest. The gun will be built around a microcontroller which will connect to all of the hardware parts inputs and outputs. Some of the inputs that will be connected to the microcontroller would be the power source, trigger, reload system sensor, and maybe a knob for some input changes. The power source will use a rechargeable battery able to output a minimum of 7 volts connected to a voltage amp to provide sufficient power for the gun's systems for at least one hour of

playtime. The trigger will connect to the microcontroller and using software the input from the trigger will send specific busts for the output to control the shooting. This can be implemented together with a knob or input to control the exact bursts with the trigger like single shot, automatic, or even burst mode. A shooting game wouldn't be realistic without ammunition or you would be able to shoot forever so we plan to implement an input for a reload system that will give you more ammunition after you reload the gun.

These inputs would connect to the outputs involved in the gun which could include the infrared emitter, LCD, and RGB LEDs. The infrared emitter will be the main output and be able to emit infrared light roughly at a wavelength of 940nm and up to around 40m in any type of bust or pattern required. Another output could be a LCD display that could show the player information about the game such as points, ammo count, health, and much more. Finally, we could have RGB LEDs around the gun to add some cool colors to the gun that could show the team color or change to red if you have been shot. These were just some of the basic inputs and outputs that our phasor gun could encompass but many more features could be added.

Secondly, we have the vest which is a separate design and will have a microcontroller to connect to its inputs and outputs. The microcontroller will be able to connect to inputs such as the battery and infrared sensors and connect to outputs including vibration motors and RGB LEDs. The power source will use a rechargeable battery able to output a minimum of 7 volts connected to a voltage amp to provide sufficient power for the vest systems for at least one hour of playtime. There will be a total of five infrared sensors on the vest two in the front two on the shoulders and one on the back these will pick up infrared light and inform the microcontroller when the player is hit. Once the sensor registers you have been hit you will feel the vibration motors turn on and the RGB lights will turn red to show you have been hit. These are just some of the basic inputs and outputs that could be involved in designing the vest as we can incorporate more features.

So now that we know how the phasor gun and vest work on a technical level how are we able to incorporate all of these features together into a working laser tag game? In each gun and vest, we plan to implement a system to connect the vest and gun to allow for seamless communication between the two. This connection will most likely be done via WIFI or Bluetooth technology which will allow our microcontrollers to be able to communicate with each other. Once the microcontrollers can connect we can implement more technology into the design.

1.3 Similar products

Laser tag is a very modern idea with an almost endless amount of products available on the market. Not only have there been other products on the market but even multiple other projects have been made in senior design at UCF using a laser tag system. These projects will be helpful for us as we can use them for information on their process to learn from their mistakes and achievements. That being said, our project will not be a copy of an existing design and we will think of more ways to incorporate new ideas and designs into the game of laser tag.

1.4 Objectives and Goals

The main objective and goal for this project is to engineer a working laser tag system that can replicate the dynamic experience of playing laser tag. By utilizing modern infrared and sensor technology, we will be able to accurately detect “hits” between the user and record the data. Some small goals and objectives are listed below.

Overall Final Objectives

- Build a working laser tag gun that emits infrared lasers.
- Build a working vest that can detect infrared lasers.

These overall final objectives are overarching goals that we need to achieve to complete the project. These goals can further be simplified as listed below.

Laser Gun Objectives

- Utilize an LCD display to show information about the game and gun.
- Emit infrared lasers to shoot at other users.
- Be able to properly reload and reset the amount of bullets in your gun

Vest Objectives

- Utilize sensors to detect whether you were “shot”.
- Give feedback to throw vibration motors to tell if you were “shot”.
- Record data and show where you were “shot”.

Stretch Objectives

- Transmit the data to a computer to report on fatal shots or unfatal shots
- Replicate a recoil system for the laser guns
- Connect through wifi or Bluetooth.

2.0 Components Research

Within our project's design, there are many different components communicating with each other to properly recreate a laser tag system. These components require extensive research in order to confirm that they connect and function properly. Some of the components that will be used will include a communication module, LCD display, haptic feedback, sensors, and LEDs.

2.1 Printed Circuit Board (PCB)

The PCB is the main connector of components in this project. The main goal on the hardware side of our project is to design an advanced PCB that is compact and effective. The PCB will connect the MCU, any controllers, and the WIFI module so that they can efficiently communicate with each other. The reason for the requirement of the PCB is for the optimal design that is an industry-standard. We plan to make our PCB single-sided with one copper layer since we have a low component density.

2.2 MicroController Unit (MCU)

The microcontroller unit is the central part of our system that controls the different I/O

peripherals such as RGB LEDs, motors, sensors, and displays. It is essentially the brain of the laser tag system, it's responsible for controlling the operation of the laser gun and the vest, interpreting signals from the infrared (IR) sensors, and managing the game's scoring system. The choice of microcontroller and the software it runs can greatly affect the performance and features of the laser tag system. The software for this system is mainly written in C, allowing us to have more flexibility and control over the system operations.

2.3 Power Supply Unit (PSU)

It is another important goal to implement the design of the Power Supply Unit. To design the power supply unit, we will be using a voltage regulator, diode, and capacitor. We use the voltage regulator so that the electronic components in our system can utilize the voltage from the battery. The diode rectifies the voltage that is drawn from the battery. Lastly, the capacitor filters out any AC components. The PSU will also have its own smaller PCB. We expect the PSU to offer an approximate 1 hour of playtime and produce a minimum output of at least 7 volts. Possible options for the battery are a 2000 mAH rechargeable battery pack from Amazon or possibly simple AA batteries.

2.4 Infrared Emitter

The main aspect of our project is the laser. This consists of a gun with a 5mm IR LED which emits infrared light when the trigger is pulled; this is perfect for trying to emulate the function of a real gun. This light can be coded to help identify which gun did the damage to the user. The IR beam emitted carries unique frequencies that can help with player identification. For the project, we are looking at possibly getting either a T1 or T2 emitter. Some benefits of the T1 are the longer range and small area of effect while the T2 offers a more compact design as well as a cheaper option.

2.5 Infrared Receiver

The vest is another key component, it will be required with multiple IR receivers. These receivers are tasked with detecting the beams from the infrared light from the guns; these are done through optical fibers. When a sensor on the vest is hit it will inform the system and keep track of the damage or scoreboard. The vest will be equipped with receivers on both shoulders, the stomach, and the back. Each zone could individually flash and vibrate allowing players to easily tell where they've been hit by their opponent. Some possible options for the IR receiver are photodiodes or phototransistors as both generate a current when exposed to light; phototransistors may be better as they can offer better detection in certain lighting.

2.6 LCD Display

In laser tag in order to make the gameplay as interactive as possible, a display will be used to show important information to the player. Key information such as the amount of ammo left, scoreboard, player's health, and player's record (kill/death ratio). A display will allow for a better gameplay experience between both players and overall a useful peripheral that facilitates the core of the laser tag.

The LCD1602 is a character-type liquid crystal display that is 16 by 2 in resolution. This is controlled by the MCU and will display information provided by the Bluetooth modules. The MCU module will be able to receive information from its counterparts when a laser receiver has detected a hit; and then will update the kill counter. Furthermore, it will keep track of the ammo capacity of the laser guns and when the user should reload. For the LCD1602 to display correctly, GND must be connected to a resistor, this value will determine the contrast for a clear and visible display.

2.7 LED

In many laser tag systems, RGB LEDs are installed in each sensor block on the player's vest. When the player is hit a system of green LEDs turning red can visually show that the player has been hit. These LEDs can also be used to indicate which team the player and its opponents are in. In addition to indication when a player's been hit LEDs can also be used to indicate different game states or game modes. For example, a quick draw game mode where both players' LEDs are red to start off and light up green to indicate 'go', then whoever is shot first will turn red again. Peripherals like LEDs are a great way to enhance a player's gameplay and immersive experience, accompanied by motors for vibrations and other sensors, it makes for a truly captivating system.

2.8 Haptic Feedback

Another aspect of human-machine interaction that goes under the radar is Haptic Feedback. Most people don't realize it but the phones we use every day while we type, and long press have tactile feedback that makes it immersive for the user. Similarly, in Laser Tag, feedback is very important; this allows for the user to be able to feel the laser gun shooting and know when they got hit. This feedback can make the game more realistic and engaging.

Motors can be used to generate vibration or movement while tactile buttons can provide a distinct 'click' sensation when pressed. These elements can significantly improve the intuitiveness and the overall responsiveness of a device.

2.9 Communication

Laser tag has a variety of hardware accompanied by great software that allows successful function. One of the most important factors of the gameplay is wireless communication between the players. Assuming that there are two players with each two guns, the system must accurately and efficiently update with reasonable delay in order to maintain plausible results. There are many choices of wireless communication available today each with its own pros and cons. Some include Wi-Fi, Bluetooth, wireless LAN and much more.

For this project, the most suitable is Bluetooth as it is cheaper and easier to work with the peripherals. Furthermore, there are many ways this can be configured, there are microcontrollers with built-in Bluetooth such as the STM32WB multiprotocol MCU's that can run Bluetooth Low energy 5.4 as well as 802.15.4 wireless protocols. Another option is a separate module for Bluetooth such as the HC-05; regarded as one of the most

popular choices in embedded systems as it allows for up to 10 meters of range with a rate of data up to 1Mbps. Using multiple chips like the MSP430G2553 and multiple HC-05 Bluetooth modules, a stable wireless communication link between a laser and receiver can be made.

3.0 Required Specifications

This project requires many specific specifications in order to fully function together properly. Making requirements on these specifications can help us set minimum goals for what each component must achieve.

Table 1. Table of Specifications

Specifications	
Sensor Distance	Be able to sense IR light from distances of **20 meters**
Laser Gun Dimensions	The size of the laser gun will be **3”x10”x25” inches**
Gamemodes	The laser tag system will allow **2 different game modes**
Battery Life	The battery will allow at least **1 hours** of playtime
Areas of Receivers	The laser tag system will consist of at least **3 areas of hits** per vest unit
Battery Voltage	The battery will be able to output a minimum of **7 volts**
Infrared Lights	The infrared lights are expected to emit light at a **wavelength of 940 nm**
Motors	The motors will be able to spin at a rate of **16000 RPM** at **3 volts**

3.1 Hardware Specifications

- A Microcontroller Unit (MCU) and a designed PCB are required for the laser gun and vest.
- RGB LED with an RGB Controller will also be added to the laser gun and vest.
- Both the vest and laser gun will have a WIFI/Bluetooth module in the PCB with an antenna to receive the signal.
- The vest will be equipped with an Infrared receiver so that it can be able to detect when the laser gun has hit it.
- In addition, the vest will have a Servo Motor Controller to operate the vibration motors; this will be useful in alerting the user when they have been hit.
- Both the gun and vest will utilize a battery as well as a voltage amp that will make up the Power Supply Unit (PSU). The battery life of each system is estimated to be 2 hours.

- The laser gun will be equipped with an LCD display to show the user data
- A trigger button, recoil buzzer, and reload button will also be equipped onto the laser gun.

3.2 Hardware Flow

A small simple diagram that creates a basic flow for how the hardware components for each vest and gun would follow.

Figure 1. Laser Gun Hardware Flowchart

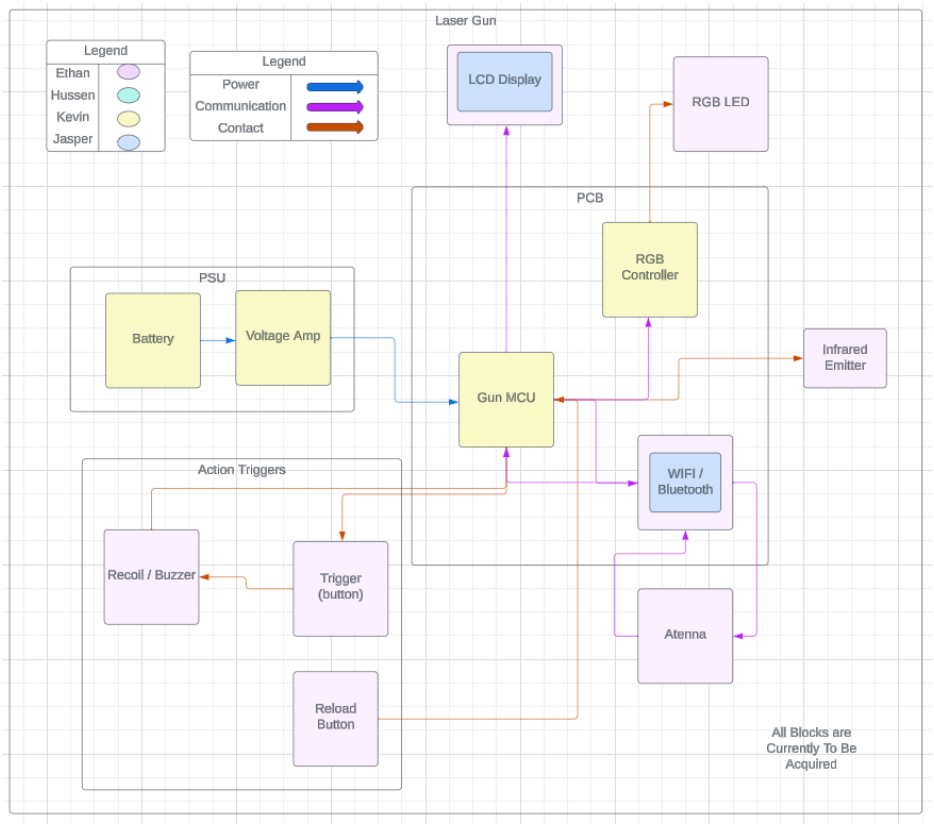
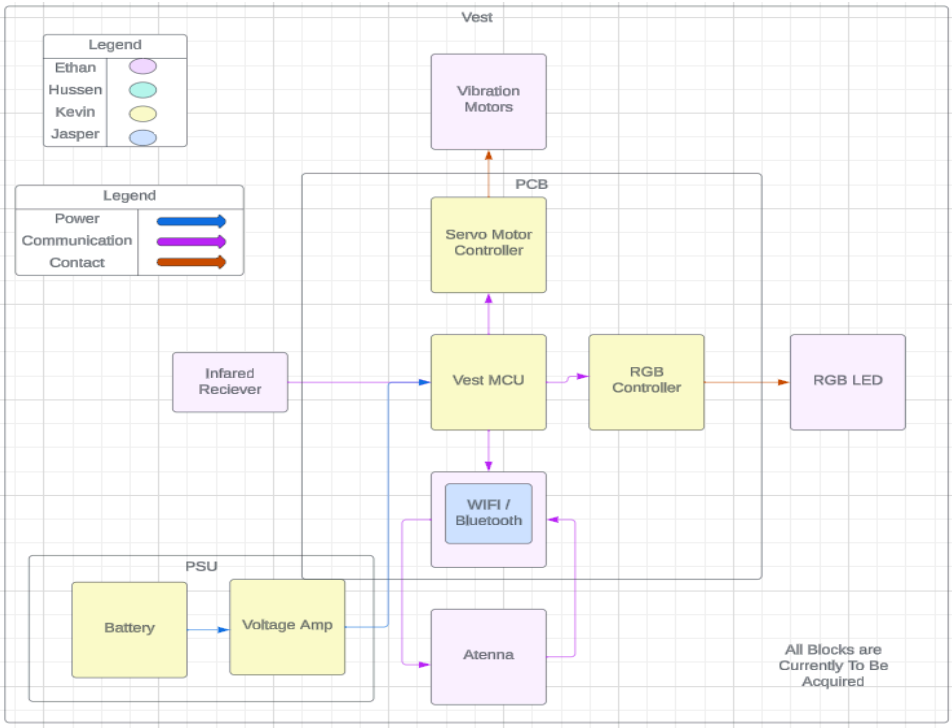


Figure 2. Vest Hardware Flowchart



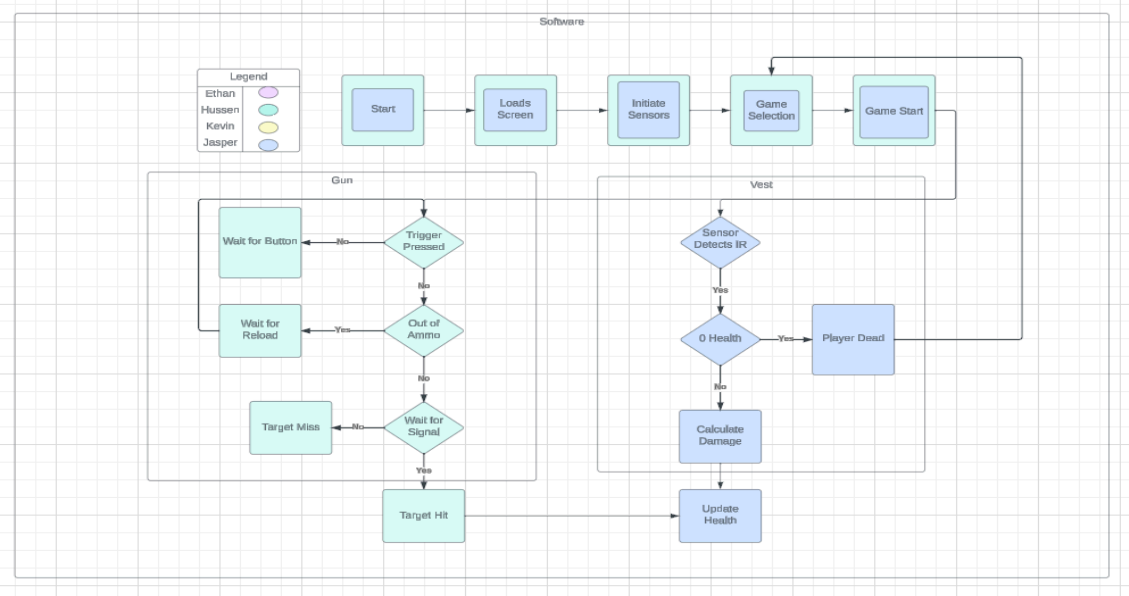
3.3 Software Specifications

- The software will be able to start or power up the system.
- The software will be written with different game modes which will control individual elements of the game.
- Be able to access and control the inputs and outputs from the main hardware devices.
- Hold information like a player's ammo, health, team, and much more.
- Software will be able to run tests on each individual device to make sure it's functioning correctly.
- Have functioning delays and timers for integrating the inputs to be able to control the output's timing correctly.
- Interrupts or checks for when the inputs detect and are able to sufficiently output the results.

3.4 Software Flow

A simple flowchart that the software developers on this team will use to create the software components for the prototype.

Figure 3. Software Flowchart



4.0 Project Milestones

Having a set of milestones is imperative to building a working project in the required time frame. Having specific milestones that need to be completed on our set deadlines gives us a better plan which will help the project run more smoothly. These milestones we need to set are budget, house of quality, and timeline.

4.1 Budget Estimates

The budget for this project will be divided among the members of this project. As we progress and purchase each part, we will monitor the expenses and compile a final budget report at the end of senior design 2.

The specific merchant for these purchases has not been finalized, but some potential options are listed below in the parts hyperlink table. Additionally, the specific part or the quantity has not yet been confirmed, as we can make many different changes throughout the research and design process. Furthermore, many of the items are going to be sourced through pre-owned parts among each member so the estimated cost below might vary from the final cost at the end of the project.

Table 2. Budget Table

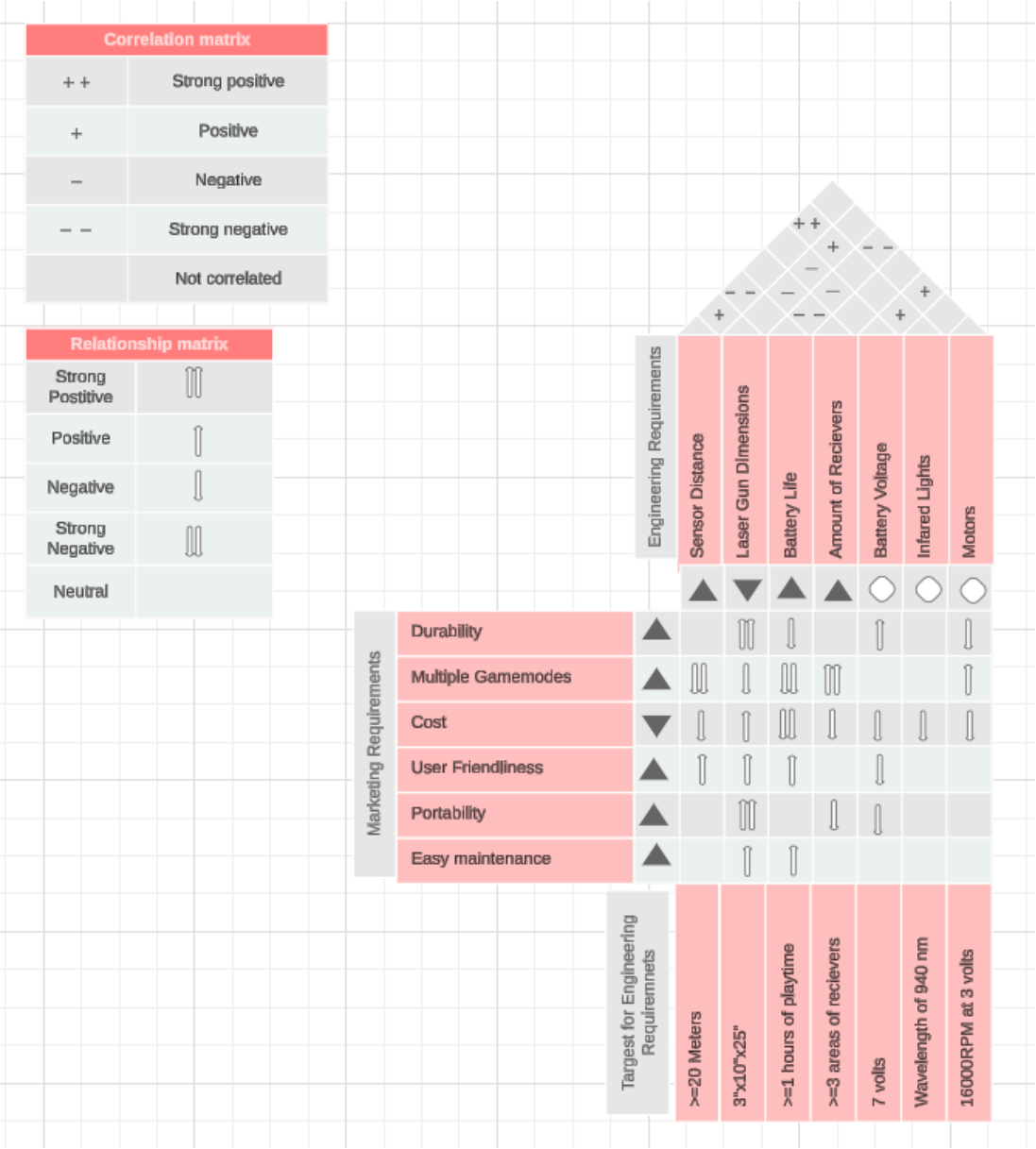
Part	**Part number or description**	**Quantity**	**Cost for each unit**	**Total Cost**
PCB Board	N/A	4	~$15	$60
MCU	N/A	4	~$15	$60
Rechargeable	2000 mAh	4	$19.99	$79.96

Battery	11.1V			
LCD Display	HD44780	2	$8.99	$17.98
LED lights	Multicolor 5mm	1 (Pack of 100)	$6.75	$6.75
Protective Vest	Black Tactical Vest	2	$28.99	$57.98
1kg Black PLA filament	2.85mm PLA Filament	2	$24.99	$49.98
IR LED	TSAL6100	2	$0.55	$1.10
IR Reciever	TSOP34856	10	$1.29	$12.90
Tactile Button	Tactile Push Button Switch	1 (Pack of 100)	$4.99	$4.99
Motors	ADA711	1 (Pack of 4)	$6.99	$6.99
Misc.	N/A	N/A	N/A	~$50
Combined Total				**~$408.63**

4.2 House of Quality

This House of Quality diagram would assist us in establishing technical benchmarks for us to achieve while creating and researching our project.

Figure 4. House of Quality



4.3 Timeline

SD1 Project Milestones				
Start Date	Estimated Date	Deadline Date	Task	Description
01/08/2024	01/11/2024	01/11/2024	Group Formation	Members: Ethan Hoang, Hussen Premier, Jasper Steensma, and Kevin

				Veciana
01/11/2024	01/26/2024	02/02/2024	Project Idea	Meeting outside or during class to discuss project ideas
01/11/2024	02/01/2024	02/02/2024	Divide and Conquer	10 page Divide and Conquer assignment
02/02/2024	02/06/2024	02/06/2024	D&C Meeting	Meeting with mentors to discuss D&C
02/06/2024	02/9/2024	02/16/2024	Update Website	Upload D&C to the website
02/06/2024	03/22/2024	03/29/2024	60 Page Report	Submit 60-page report milestone
02/06/2024	03/28/2024	04/04/2024	60-Page Report Group Meeting	60-page report meeting with mentors
04/04/2024	04/16/2024	04/23/2024	SD1 Final Report	Submit 120-page report

Table 3. Senior Design 1 Milestones

SD2 Project Milestones				
Start Date	Estimated Date	Deadline Date	Task	Description
08/21/2024	TBD	TBD	Gather Components	Gather all missing components for the final prototype
08/21/2024	TBD	TBD	PCB Schematic	Create and finalize the PCB Schematic and order the PCB for the prototype
08/21/2024	TBD	TBD	Overall Schematic	Finish the overall schematic for the project
08/21/2024	TBD	TBD	3D Parts Cad and Printed	Finish and print all 3D parts to assemble for the project
TBD	TBD	TBD	Prototype Test	Start the testing of the project

TBD	TBD	TBD	Prototype Adjustments	Troubleshoot any issues with the prototype
TBD	TBD	TBD	Prototype Completion	Finish the prototype to present
TBD	TBD	TBD	Project Finished	Finalize and fix small issues
TBD	TBD	TBD	Project Presented	Present the final project to the board

Table 4. Senior Design 2 Milestones

Declaration:

We hereby declare that we have not copied more than 7 pages from the Large Language Model (LLM). We have utilized LLM for drafting, outline, and comparing.

Appendix

Sources:

1) “Generate a Laser Tag Toy that has an orange tip” prompt: ChatGPT-4, April 2023 version, OpenAI, 29 January 2024, chat.openai.com
2) https://www.instructables.com/Voltage-Amplifier/
3) https://www.homemade-circuits.com/how-to-design-power-supply-simplest-to/
4) https://lasertaglsd.com/project/technology-emmiters/

Part Hyperlinks:

IR LED	https://www.digikey.com/en/products/detail/vishay-semiconductor-opto-division/TSAL6100/1681338
IR Reciever	https://www.digikey.com/en/products/detail/vishay-semiconductor-opto-division/TSOP34856/4074519
Rechargeable Battery	https://www.amazon.com/Cuzieey-11-1V-2000mAh-Gun-Battery/dp/B0B5RJYR7J/ref=asc_df_B0B5RJYR7J/?tag=hyprod-20&linkCode=df0&hvadid=617467055999&hvpos=&hvnetw=g&hvrand=4633827575762848 19&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=1015153&hvtargid=pla-1731688288504&psc=1&mcid=6b0c8fa56ab736f5b712a632f3977d6c&gclid=CjwKCAiAtt2tBhBDEiwALZuhAKjPVZhAIkqygQnpZJkJER4Ne_IeRljRIwFwCTt5p8EDkG5_TYWemxoCDZQQAvD_BwE
LCD Display	https://www.amazon.com/HiLetgo-Display-Backlight-Controller-Character/dp/B00HJ6AFW6/ref=asc_df_B00HJ6AFW6/?tag=hyprod-20&linkCode=df0&hvadid=312322349988&hvpos=&hvnetw=g&hvrand=10066308934456718597&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=1015153&hvtargid=pla-585256965018&psc=1&mcid=6183eaeb58823389a3359470e66481d7&gclid=CjwKCAiAtt2tBhBDEiwALZuhAIGrU3by--mfrFC64FU6I_SwYXzMJbtA04Ngf1nEL_saMkjWLYaSLxoCJ4UQAvD_BwE
LED Lights	https://www.amazon.com/eBoot-Pieces-Emitting-Diodes-Assorted/dp/B06XPV4CSH/ref=asc_df_B06XPV4CSH/?tag=hyprod-20&linkCode=df0&hvadid=167146990738&hvpos=&hvnetw=g&hvrand=45176668625297424 02&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=1015153&hvtargid=pla-369941417757&psc=1&mcid=5ea231ba612a3f49b0b6b3e9bae8a868&gclid=CjwKCAiAtt2tBhBDEiwALZuhAG2O0ANWanv1sRJtS4fbCrIBSDYZ7_Nje9dmvv-Yv9VRndGEfOO9NhoCvogQAvD_BwE

Protective Vest	https://www.amazon.com/PYangTian-Tactical-Adjustable-Protective-Equipment/dp/B0CNJZ1N1M/ref=sr_1_20_sspa?crid=1Z6WG8A6CFBM3&keywords=paintball+protective+vest&qid=1706571670&sprefix=paintball+protective+ves%2Caps%2C91&sr=8-20-spons&sp_csd=d2lkZ2V0TmFtZT1zcF9tdGY&psc=1
Black Filament	https://www.amazon.com/Polymaker-Powerful-Rigidity-Filament-Cardboard/dp/B09J184B2Z/ref=sr_1_3?crid=2CEUC5INOVAGW&keywords=black+filament+3mm+pla&qid=1706571932&sprefix=black+filament+3mm+%2Caps%2C92&sr=8-3
Tactile Buttons	https://www.amazon.com/DAOKI-Miniature-Momentary-Tactile-Quality/dp/B01CGMP9GY/ref=asc_df_B01CGMP9GY/?tag=hyprod-20&linkCode=df0&hvadid=309774137275&hvpos=&hvnetw=g&hvrand=17049300603544878119&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=1015153&hvtargid=pla-640514760452&mcid=1fc6d42692553f1ca9b13fc5c0e2dcf3&gclid=CjwKCAiAtt2tBhBDEiwALZuhAOCzJUQjeY3nJs-UA27ZmG0J-aQKDCxLSP2Ca8dBuQAQ-OGiXnDqpBoCIk0QAvD_BwE&th=1
Motor	https://www.amazon.com/BOJACK-Pcs-Type-130-EK1450/dp/B09FPXF1QK/ref=sr_1_6?keywords=cheap%2Bmotor&qid=1706574257&sr=8-6&th=1