PURRFECT CLEANER

Automatic Cat Litter Box

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Group 5

Samuel Durkee - Computer Engineer
Kayla Funchess - Computer Engineer
Eliezer Roman - Electrical Engineer
Junxu Zeng - Electrical Engineer

Reviewers

Dr. Abichar
Dr. Yuan
Dr. Sun

Project Background and Goals

Cat litter boxes have proven to be a highly successful method of regulating feline waste. Litter boxes allow cats to relieve themselves in a comfortable and low-maintenance environment for the owner. However, in the past, owners had to scoop the cat excrement manually. Over the years, companies have designed better-quality litter boxes that automate the poop scooping and bagging process. Our team's goal is to further the development of modern automatic cat litter boxes by making economical improvements and adding quality features.

Automatic Cat litter boxes are retailed from around $150 on the low end to $700 for higher quality devices. For many boxes on the cheaper side, there are very minimal features and lower overall performance ratings from customers. Our team aims to produce a cost-efficient automatic litter box that provides quality features to the consumer while maintaining a lower price. These features will include safe-cat features to ensure the litter box will not run when the cat is present, accessible waste bag collection and management, a mobile component to allow the litter box's storage to be monitored and cleaned remotely, and a mobile notification to indicate when the litter box storage needs to be changed.

As technological innovations have led to more changes in the quality of life of modern devices and applications, the cat litter box can be further improved. Increases in feline waste storage capacity and sealing will allow for users to change the waste less frequently. For example, a future possibility for automatic cat litter boxes is vacation mode. During vacation, the cat waste will be stored in heat-sealed bags to minimize odor while the owner is on holiday. Furthermore, sealed bags will allow the automatic cat litter box to support multiple bags, as a new bag can be installed when the previous one is sealed. The concept of improvements in cat waste sealing is a stretch goal for our team.

Cat litter boxes have the potential for automatic litter replacement and waste sealing hygienic improvements. A litter box that replaces its litter will provide a longer time between user interactions with the device, improving the quality of life. Paired with better waste management, an automatic cat litter box has the potential to be changed far less than even current state-of-the-art devices. Our team's stretch goal is to not only make an automatic cat litter box that is competitive with our devices on the market but also add unique and effective features that have not been marketed.

Our group intends to create a practical, multi-featured automatic cat litter box that is economically cheaper than other devices while providing quality features.

Our group has the stretch goal of delivering new innovative features to the automatic litter box.

Objectives and Project Motivation

Our group aims to develop and design a practical automatic cat litter box with multiple quality-of-life features. Additionally, our team intends to cut the price compared to other high-end, multi-featured cat litter boxes on the market. We want to make an automatic cat litter box with cat safety features, advanced excrement management/storage, and mobile features allowing remote access and user interface.

Our group intends to make a litter box that supports cats of varying shapes and sizes. The group's motivation is to create a quality-of-life cat waste cleaning device that improves the quality of life for users, from reduced prices to added features. Our team is set to produce a device that can be marketed to consumers at a low price compared to upscale products while still providing the same features. We want to enhance the livelihood of cat owners by creating a product that provides their cats with a safe and efficient waste-cleaning environment.

Description of features/functionalities

Our project will include many features to enhance a modern litter box design. The first significant feature our project will consist of is the innovative, safe feature for cats. Multiple weight sensors will be built into the box to detect excess weight inside the litter box. Specifically, when the device goes through a cleaning cycle, any trigger to the weight sensor will stop the device from finishing until the weight is removed. The device will include a standby mode when it is interrupted, which keeps the device from operating until the interruption is fixed.

The next prominent feature our project will include is a user-friendly mobile component. The feature will support a mobile app that allows users to sign up and connect their account to an automatic litter device. Once connected, the users can monitor the excrement stored in the litter box waste compartment. Additionally, the app will notify when the litter box waste has reached its limit. The limit will be determined by a weight sensor that is set to a specified amount (ex., 5 pounds). Finally, the device will track the cat's weight through the weight sensor and display that information in a chart through the app.

Existing Projects/Products

When we decided that we were going with the idea of making a cat litter box cleaner with some additional features, we searched throughout the internet for multiple versions and examples of cat litter box self-cleaners to get a basic idea of how it could work and look. In order to ensure we had a project idea that was able to be worked on extensively for the duration of two semesters, we made sure when looking for products that they had differing features and functionalities. This was incredibly important so that we could have insight into which features seemed more effective and what we could take as inspiration for our own version of a cat litter box cleaner.

We searched on various commercial sites such as Amazon and sites dedicated to cats' care products. One of our main concerns was about how the cat litter would be moved and deposited so when searching for various examples, we made sure that the ones we found had different ways of dealing with the unclean litter. This would allow us to decide what method of disposing of the litter would be best for our project.

One of the examples we viewed was called Nature's Miracle Multi-cat self-cleaning litter box. Their self-cleaning litter box has a built-in rake that is used to clean the litter, which we thought was an effective feature of the product. It also included motion detection sensors that would detect whether the cat was in the box in order to prevent cleaning the litter while the cat was still inside. The product had many solutions to problems not easily thought of at first glance, for example a light for the cats for when it gets dark and a ramp for them to gain access to the litter box to limit the possibility of the dirty litter getting on the floor. The Nature's Miracle company had established many features that gave us more thought on how to implement our project and a useful reference to look back on during the duration of this project.

We had also discovered a self-cleaning litter box created by engineering students at the University of Illinois. They decided to make an elevated version of a self-cleaning litter box with a closable door. The features of their self-cleaner was that it had used a rake instead of a shovel to clean the litter, motion sensors to detect if the cat has entered the litter box, and sealer for when the wasted dumped in the bag it would be sealed via a heat sealer for clean disposal of litter. This previous project had made us understand what goes into creating a product like this and how we could elevate it and how to proceed with it throughout the two semesters.

In conclusion, researching on various sites for more information of self-cleaning litter boxes has given us some more insight of what the standard requirements

are for it to work. The basic features needed to operate, and optional features all gave us many ideas on what to implement in our project.

Key Specifications

Below are the specifications for the parts we are using to build our version of a self-cleaning litter box. Each part has its own set of specifications regarding the width, height, or requirements. The three demonstrable specifications are the scooper moving the poop in the bag, motion sensors being able to detect if the cat is in the litter box, and weight sensors as a secondary precaution to detect if the cat is in the litter box.

Three Demonstrable Specifications	
Motion Detection	Checks if the cat is inside the litter box to prevent the cleaning cycle from occurring
Weight Detection	Checks before cleaning the waste to see if the cat is the box and for minor weight increases such as waste to begin the cleaning process
Waste Removal	During a cleaning cycle to waste is removed from the box using a scooper and is placed in a waste bag

Casing	
Maximum Height	20 inches
Maximum Width	30 inches
Maximum Weight	7 kg
Minimum Weight	4 kg
Maximum Weight for cat	3 kg
Power	
Max Consumption	<1,000 watts
Scooper	

Maximum Width	11 inches
Internet Adapter	
Data Transfer Rate	<1,200 Megabytes per second
Waste Bags	
Maximum Width	14 inches
Maximum Height	19 inches
Minimum Width	9 inches
Minimum Height	5 inches
Motor	
Power	12 V
Weight Sensors	
Maximum Width	3 centimeters
Maximum Height	4 centimeters
Quantity	8

Figure 1A: Specification Chart

Hardware Block Diagram

The hardware block diagram is shown in **Figure 2A**, a visual representation of the system that we will be creating. Starting from left to right, the weight sensors are used in the litter compartment, continuously reading the weight and sending the information to the MCU through an Analog to Digital Converter on the PCB. The MCU takes this information in order to determine if the cat is currently in the litter, and to use it to prevent the motor from turning on while the cat is inside. The system will also be using two buttons to allow for user intervention. The first button will be used to put the system on standby, this can be used for when the owner would like to replace the current cat litter, clean the container, or remove something that is stuck in the container.

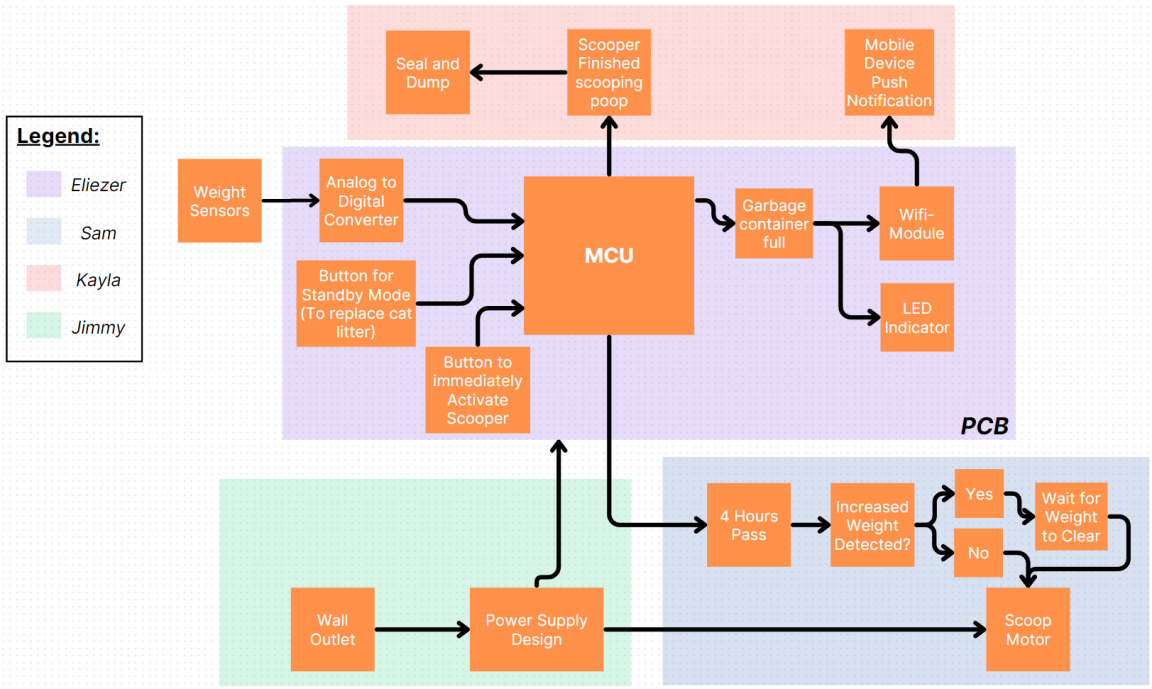

Figure 2A: Hardware Block Diagram

The second button is to have the scoop motor run immediately; this allows the owner of the feline to manually remove any poop that is currently sitting in the container. Sometimes the poop from our pets comes out, as we will say, "unusual" and can have a more pungent odor that may need to be removed quickly; the button allows this quick removal. We added this because we planned to have the scoop motor run in specific time intervals, around every 4 hours. This may seem like an extended amount of time, but an average cat will poop every 12-24 hours, depending on nutritional intake. Of course, this would mean that at any time of the day, the cat can poop in the container, and having a four-hour interval allows the motor to scoop morning, afternoon, and night, covering all times of day for when a cat might poop.

The following equipment on the PCB is the Wifi-Module and the LED indicator. The purpose of these two is to notify the owner that the container for holding the cat feces is full. The Wifi-Module will connect the system to an application for sending push notifications to the owner's mobile device. The LED light will be used for a visual indication on the system itself for the feces container to notify the owner that the container is full. Everything in this system will, of course, need to be powered, and we have elected to create a wall-plugged power supply. Since this system will mainly be present in the owner's home and never moved, a battery source was not needed. Our options for powering the system through the wall remain open for discussion. We can choose a simple Nema 5-15p cord that connects to an AC/DC converter and directly feeds the PCB and

the motor, or we can have the connection to the PCB be a USB type A or C connection, like how a mobile device works.

Software Flowchart

The software flowchart is shown in **Figure 3A**. The self-cleaning litter box provides two user inputs: "Sanitary Mode" for manual cleaning initiation and "Start Scooping" for an immediate scooping cycle. During normal operation, when the timer goes off the device checks for cat presence using weight sensors. If a cat is detected, the device enters standby mode which will start scooping once the cat leaves; otherwise, the garbage level is checked before scooping. If the garbage is full, the device enters standby mode with an LED indicator. If not, the device proceeds to activate the scooping mechanism.

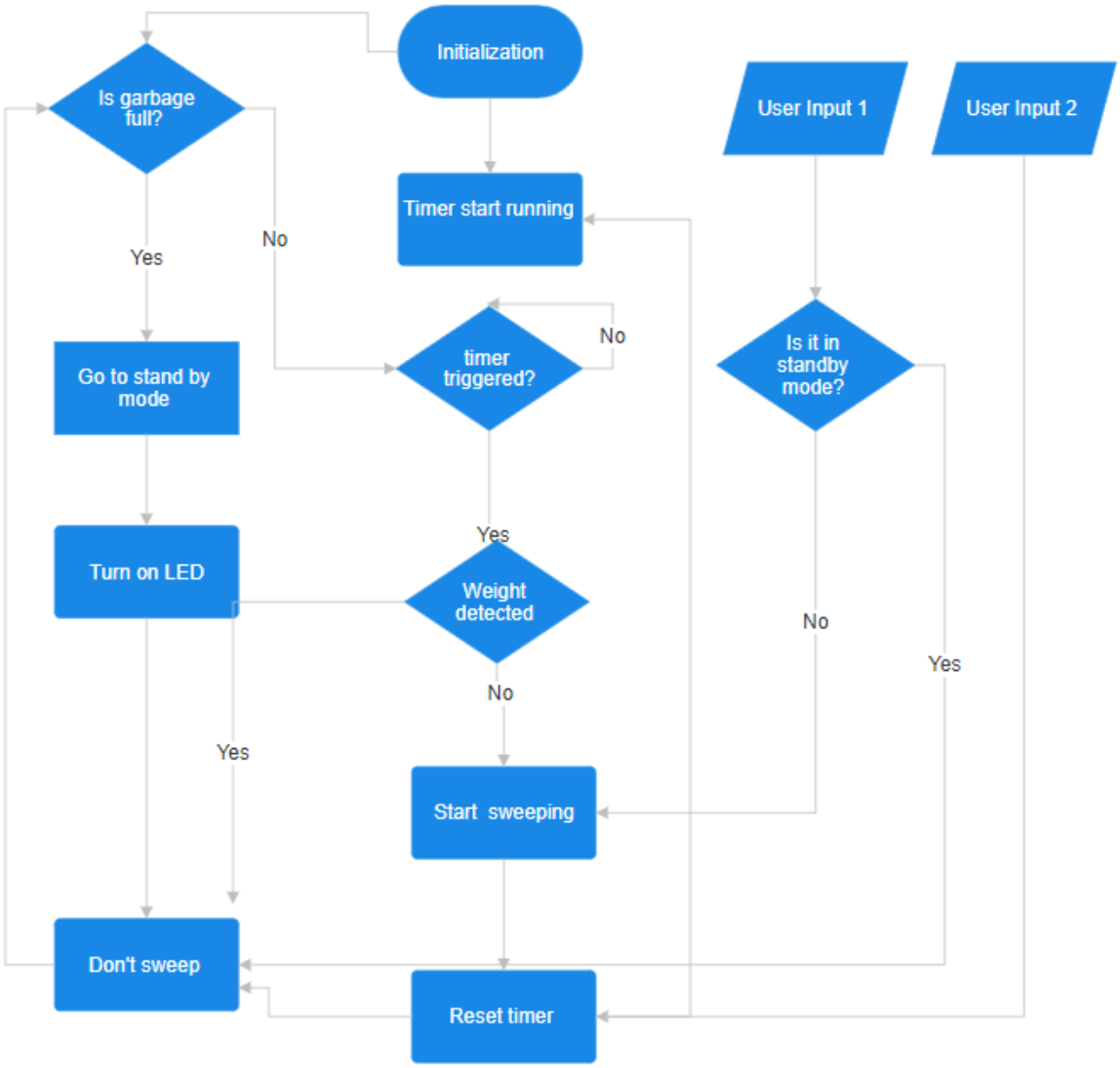

Figure 3A: Software Flowchart

House of Quality

The House of Quality (HoQ) diagram is a structured matrix connecting customer requirements with corresponding engineering characteristics. It consists of customer needs listed on one side, engineering features on the other, and a matrix indicating the relationships and priorities between them.

- **Compatibility**: Ability to work with a variety of cat litters
- **Stability**: Durable construction to withstand regular use
- **Mechanism**: Scooping motion
- **Functionality**: the functions and features of the product

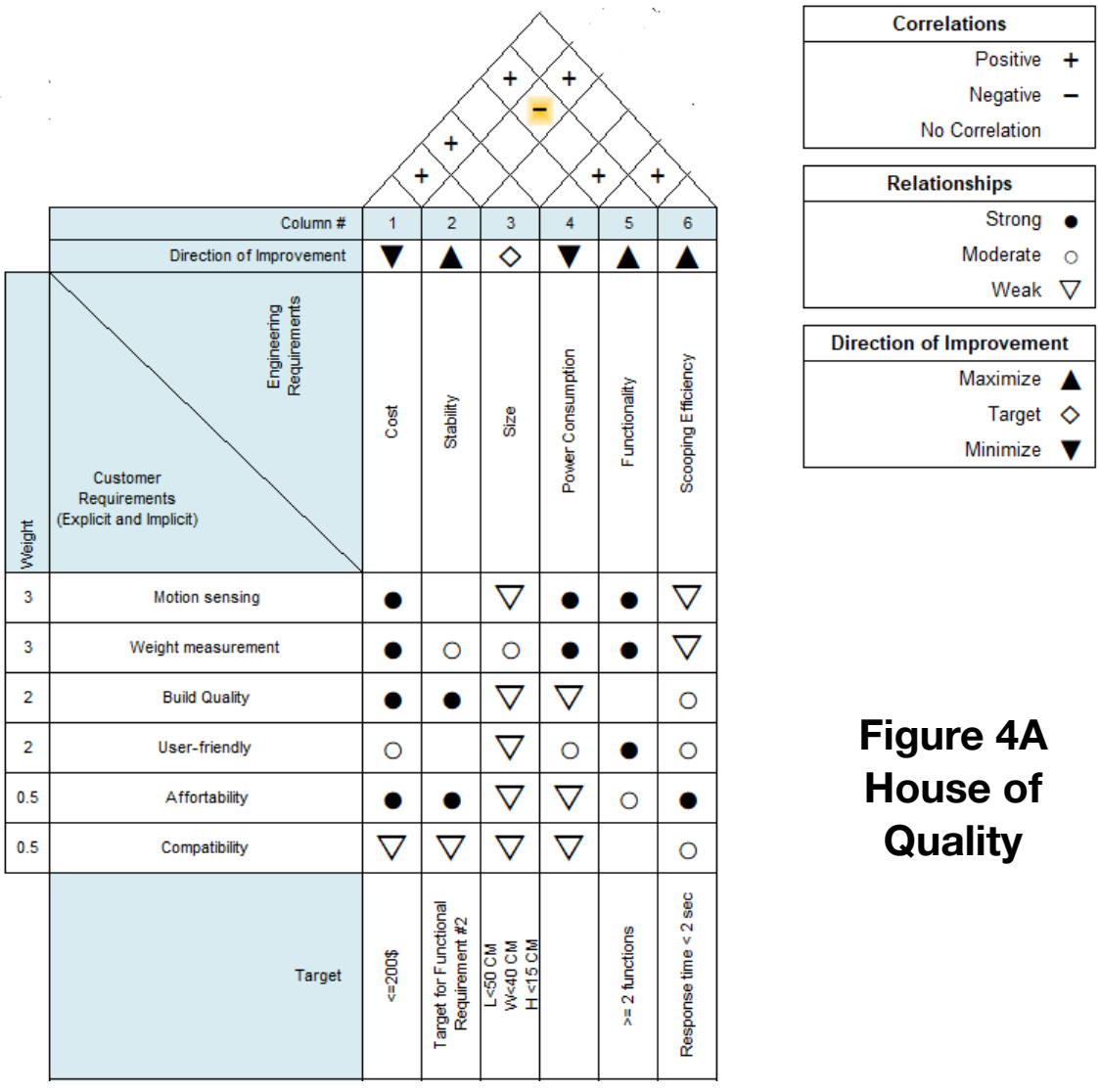

Figure 4A House of Quality

Pricing and Budgeting

The estimated price for this system is shown in **Figure 5A**; the prices listed in the table are average prices between multiple websites, such as Amazon and Temu, and multiple brands of parts needed to create the system. For example, button manufacturers can create simple tactile buttons or buttons with a locked switch to keep the button pressed. Each button has a different purpose, but for our system, simple tactile buttons are enough to meet our requirements, and the extra feature for smart locking on the button is unnecessary. Along with the component being priced is the seller that the price was taken from, and the decision to choose the seller was based on the price and time for delivery of the parts. For the PCB assembly, we decided on JLCpcb, a reputable company recommended by past senior design students and engineers currently in the field. JLC was also chosen because it incorporates the software that will be used to make the PCB schematic, the EasyEDA PCB design tool. The weight sensors we will be using are four separate weights that will be placed in each of the corners of the litter. Along with the weight sensors will be an analog-to-digital converter to convert the pressure input from the container to a digital output for the MCU. The MCU is labeled as “To Be Determined” for the time being, and an estimated price was listed. The reason for this is that

Component	Price ($)
PCB Assembly - JLC	25
Weight Sensors - Amazon	9
MCU - TBD	25
Internet Adapter - Amazon	10
Power Supply - Assembly	12
Bags - Amazon	15
Motor - Assembly	20
Casing - Assembly	20
Buttons - Amazon	6
Scooper - Amazon	20
Total	162

Figure 5A: Price Table

we are still trying to determine which MCU would best fit our requirements, as well as an MCU that has a beneficial platform to work with. The internet adapter is a separate module to handle communication with the internet for our app integration; the price for this adapter is also an estimate, as it would depend on the MCU we choose. The power supply is labeled “Assembly” because it is a

component that must be built according to specific standards, whether we choose the Nema 5-15P or a USB connection. The bags are self-explanatory; they are meant for the garbage container to store the cat feces. The motor and casing depend on one another; how we choose to make the casing affects the type of motor we should use to have it operate the best for scooping the feces. The buttons were explained earlier; we only need simple tactile buttons for user interaction with the system. Finally, we have the scooper with the type of shape, blade count, and curvature that will be made based on the form of the casing, which will be put up for discussion along with the casing and motor type.

Our goal for the pricing of the cat litter system is to either keep it below other similar products on Amazon, Temu, etc., or match the price with more features. An example is Nature's Miracle™ Multi-Cat Self-Cleaning Litter Box on Amazon. This litter system is a similar product that we are trying to create, it has a self cleaning motor system whenever the cat is done doing its business on the litter. It has a switch to change the system from Auto to Maintenance, similar to our idea of having a standby button to be able to clean or fix a small problem, and it has a storage system. The difference is that the motor is ONLY for cleaning, it does not scoop that poop for the owner, and the storage system stores a manual scooper. Removing the poop from the litter is still done manually with the scooper in the storage area, but cleaning is done automatically. Our idea is to do the opposite, have an automatic scooping and storage system for feces instead of automatically cleaning the container.

Project Milestones for SD1 and SD2

Task	Description	Start Date	Tentative End Date
Forming a Team	Finding 4 teammates for Spring/Summer semesters	**1/8/2024**	**1/11/2024**
Brainstorming Project Ideas	Discussing potential ideas	**1/11/2024**	**1/21/2024**
Individual Research	Each member conducts their own research on chosen idea	**1/21/2024**	**2/2/2024**
Divide and Conquer Document	Writing and finishing 10-page D&C Document	**1/21/2024**	**2/2/2024**

Divide and Conquer meeting	Having a meeting with advisor about D&C document	**2/5/2024**	**2/8/2024**
60-page Report Milestone	Starting to write and finalize the 60-page draft	**2/2/2024**	**3/29/2024**
Final Report	Writing and finishing the final 120-page report	**3/29/2024**	**4/23/2024**

Figure 6A: SD1 Project Milestone Table

Task	Description	Start Date	Tentative End Date
Ordering PCB	Ordering PCB from our chosen manufacturer	**5/13/2024**	**TBD**
Testing PCB	Testing if the PCB works as intended	**TBD**	**TBD**
Putting together all of components	Forming all the parts together to build the product	**TBD**	**TBD**
Practice Demo	Conducting a practice demonstration before presentation	**TBD**	**TBD**
Finalizing the Final 120-page Report	Reviewing and editing the final Report	**TBD**	**TBD**
Final Presentation and Demo	Presenting finished project to advisors and committee	**TBD**	**TBD**

Figure 6B: SD2 Project Milestone Table

The two tables above are our project milestones that we set to complete for Senior Design 1 and Senior Design 2. We plan to keep track and follow them strictly in order to be successful in completing our project on time.