January 30, 2019

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, BC, V5A 1S8

DoggyGo Inc.

Re: ENSC 405W/440 Requirements Specification for an Automatic Animal Ball Launcher

Dear Dr. Rawicz,

The document attached with this letter is our requirements specification document to our successful design for an Automated Pet Entertainment Toy. The goal for this Capstone Project is to create a product that will entertain our pets when we are not able to accompany them by providing them with a game to play indoors and outdoors.

The objective of the requirements specification document is to outline the high-level functionality of our product through its different design phases: Proof of Concept, Prototype, and Final Product. We will detail DoggyGo's functional and structural requirements across 4 categories: Electrical, Hardware, Mechanical and Software. We will then list the Engineering Standards and Sustainability & Safety concerns that DoggyGo must address.

DoggyGo Inc. consists of 5 outstanding and creative senior engineering students: Hongbin Lin, Junchen (Steven) Wang, Curtis Cheung, Manci (Maggie) Song and Danfeng (Sherlock) Sheng. Coming from 3 different engineering concentrations, our team has extensive hardware and software experience to aid us in realizing this proposition.

Thank you for taking the time to review our requirement specifications. If you have any inquiries regarding the document, please contact our Chief Communications Officer, Junchen (Steven) Wang, by phone (778-321-1907) or by email (junchenw@sfu.ca).

Sincerely,

Danfeng (Sherlock) Sheng
Chief Executive Officer
DoggyGo Inc.

Enclosed: Requirements Specification for an Automatic Animal Ball Launcher

Requirements Specification

Automatic Animal Ball Launcher

Solo Carnival for Pets

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Dr. Andrew Rawicz (ENSC 440)

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Abstract

This document specifies the functional requirements of the automatic animal ball launcher, DoggyGo. These requirements will be described as the building fundamentals on DoggyGo. In the next following sections, each of the system components will be explained in detail. In addition to describing each component in detail, this document will also consider Sustainability & Safety factors in our design and shall strictly obey the Engineering Standards.

DoggyGo will be composed and described in terms of the following four main systems:

1. **Mode Switching System**

   The mode switching system will allow the device to switched between automatic and manual (user-controlled) operation modes.

2. **Detector System**

   The detector system will contain a series of sensors to detect if a ball is available and whether or not the ball is safe to be launched. Through its sensors, DoggyGo will be able to detect if the ball is returned to the holder, which will in return dispense treats for the animal to enjoy.

3. **Launcher System**

   The launcher system will allow the ball to be launched at various vertical and horizontal angles and has the ability to control relatively how far the ball will go using a strength setting.

4. **Remote-Control System**

   The remote-control system will allow the user to control the launcher and treat system wirelessly when DoggyGo is in manual mode.

The remote design will be designed in such a way so that it can be stored on DoggyGo and be able to control DoggyGo in an efficient way. This will be a great product for pets to spend their lonely time with as they are able to be entertained while the owner is away from home.

Table of Contents

List of Tables

List of Figures

Glossary

ABS	Acrylonitrile butadiene styrene, or ABS, is a common type of plastic used for 3D-printing. Lego is an example of ABS plastic.
ANSI	American National Standards Institute
Arduino	An open-source hardware and software company which allows users to develop digital devices that are able to accept sensor inputs and outputs.
CSA	Canadian Standards Association
ISO	International Organization for Standardization
NFPA	National Fire Protection Association
PBT	Polybutylene terephthalate, or PBT, is another type of common plastic that is stronger than ABS and is more susceptible to wear and tear.
Pneumatic	A system that is operated using air pressure.
Proximity Sensor	A sensor that can detect presence of an object without any physical contact with an object.
Servo Motor	A motor that can perform precise control of motor rotation through the use of position feedback circuit.
Time Stepper	A time counter which is used to record the idle pulse and sending the command when the function is called
Ultrasonic Sensor	A sensor that uses an ultrasonic transmitter and detector to detect the distance of an object based on the time between transmission and reception of the transmitted ultrasonic signal.
USB	Universal Serial Bus, often used to connect devices to computers to allow bi-directional data transfers.

1   Introduction

In the past few years, the popularity of pet keeping have been cultivated as a universal trend. It is true that an abundant of researchers has indicated that people who keep pets will be healthier in both physical and mental activities compared to those who do not live with pets. Pet keeping is a very effective way to allow people who are under stress to relax. Therefore, in the recent years, there are more and more households willing to raise pets. However, with full-time day shifts for most people, keeping the pets entertained will be very difficult.

DoggyGo aims to make friends with dogs and their owners while they are out at work. DoggyGo combines several similar products that are found on the market into a single system. DoggyGo can fire a tennis ball from the launcher and provide treats to dogs. This system has the ability to be controlled in both automatic mode and manual mode. The most attractive feature of DoggyGo will be its great sustainability and high safety standards. To accomplish this goal, DoggyGo will have a complete detection system constructed with sensors to inspect the surrounding launching zone. If there are objects that are obstructing the launcher path, DoggyGo will stop its launch sequence. Users also can control the launcher and treat system manually as opposed to automated launch and dispense operation sequences. This will allow the user to adjust the angle, strength and direction of the launched ball. A high-level behavioral diagram description of functionalities is shown in Figure 1.1.
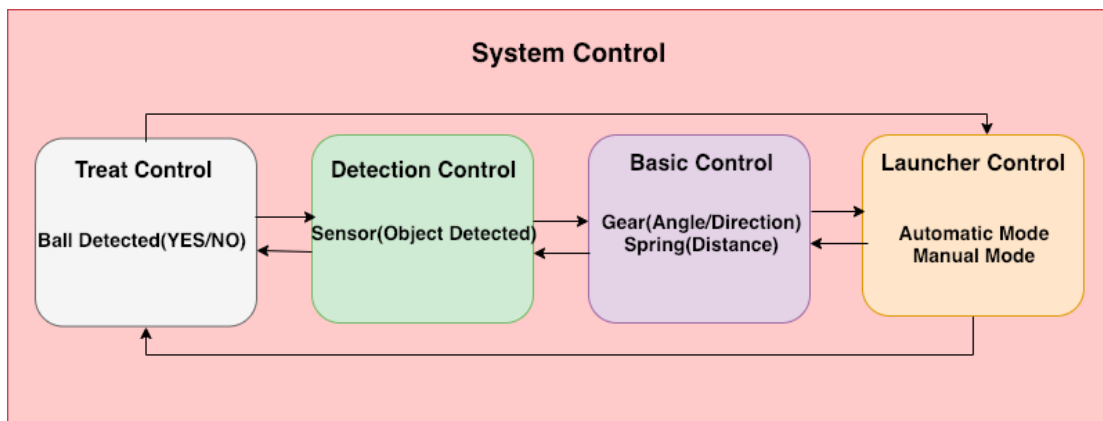
Figure 1.1: Basic Behavioral Overview

In this requirement documentation, we will introduce a detailed outline and requirement specifications. These specifications will include Functional Requirements (Mechanical, Hardware, Electrical, Software), Engineering Standards, Sustainability and Safety.

1.1 Intention

We will specify the requirements of DoggyGo as well as the Engineering Standards, Sustainability and Safety. These requirements will help us have a comprehensive understanding of DoggyGo.

1.2 Audience

This document will provide information of DoggyGo to the DoggyGo Inc. members, supervisors and potential clients: William Craig Scratchley (ENSC 405W), Andrew Rawicz (ENSC 440), Nic Zilinski (TA), and Bakhtiar Azim (TA). The functionalities and requirements will be clearly defined in this documentation. Further revisions and future documentation will base on this framework and workflow.

1.3 Requirement Classification

The following table indicates the design stages with their corresponding code names.

Table 1.1: Requirement Classification

Code Name	Design Stage
C	Proof of Concept
P	Prototype
F	Final Production Product

The specific requirements and functionalities in this document and further versions will adopt the form:

Req (Section Number). (Subsection Number). (Requirement Number) - (Design state).

For example, the first requirement of the fifth section's first subsection as the final production product can be shown as Req 5.1.1 - F.

2 System Overview

DoggyGo will include two modes of operation: automatic and manual mode. Both of these modes will be comprised of three subsystems: launcher system, detection system and treat system. The launcher system will contain a launcher with a spring to adjust the shooting strength along with gears that will allow the launcher to adjust the horizontal and vertical launch angle. The launcher system will also include a speaker that will sound a warning before launching the ball. The detection system is formed by several types of sensors: proximity sensor and ultrasonic sensors. In the treat system, DoggyGo will consist of several proximity sensors to detect if the ball is returned. In automatic mode, the treats in the treat system will be dispensed when a ball is returned to the launcher. In manual mode, users can use a remote control to control the launcher angle strength and angle along with the ability to manually dispense treats. Figure 2.1 provides a workflow diagram of DoggyGo.
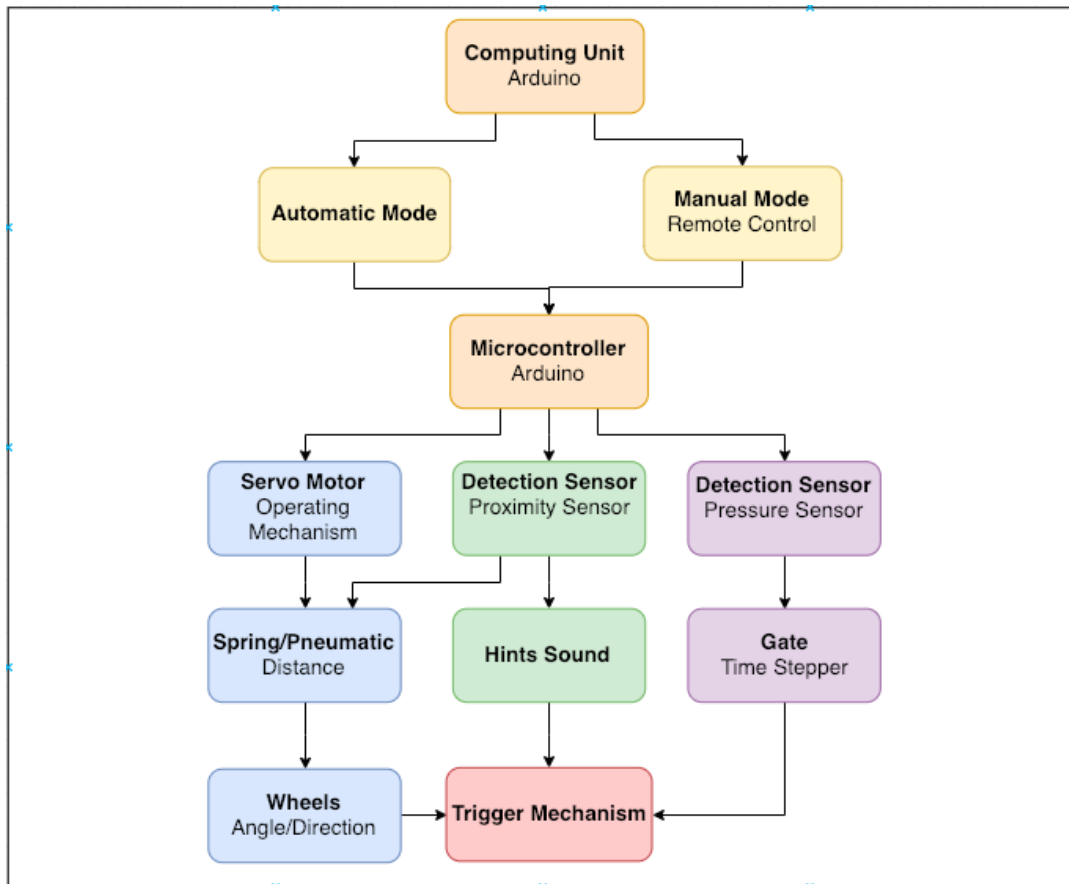
Figure 2.1: DoggyGo's System Overview

3 High Level Requirements

The high-level requirements will be mainly divided into three subprojects: the ball launcher system, environment detection system and treat system. The following are the high-level requirements which we will detail further in the subsequent chapters.

3.1 General Requirements

Table 3.1: General Requirements

Req 3.1.1-P	Adjust the angle, direction and strength to a certain value.
Req 3.1.2-P	Be able to dispense treats when the dog returns the ball.
Req 3.1.3-F	Reliably recognize the objects before activating the ball launcher mechanism.
Req 3.1.4-F	Ability for DoggyGo to be configured both automatic and manual mode.

3.2 Overall Performance

Table 3.2: Overall Performance

Req 3.2.1-C	Adjust the launcher angle/strength to achieve a relatively accurate distance for shooting.
Req 3.2.2-C	Adjust to achieve a correct angle for shooting as specified.
Req 3.2.3-C	Adjust to achieve a correct direction for shooting as specified.
Req 3.2.4-C	Sound a voice from the speaker to warn the surrounding people before a ball is launched.
Req 3.2.5-P	Launch a ball based on the adjusted distance, angle and direction.
Req 3.2.6-P	Provide a treat when the launcher detects that the ball is returned.
Req 3.2.7-P	Ability to open the treat container to allow treats to dispense.
Req 3.2.8-P	Ability to close the treat container to prevent further treats from dispensing.
Req 3.2.9-F	Detect surrounding objects in the launch zone.
Req 3.2.10-F	Pause launch sequence if objects obstructing the launch path are detected.
Req 3.2.11-F	Available to choose either automatic mode or manual mode
Req 3.2.12-F	Controlled by a remote control in the manual mode

4 Physical and Mechanical Requirements

4.1 General

Table 3.1: General Requirements

Req 4.1.1-C	The device shall be ergonomically designed.
Req 4.1.2-P	The weight of device shall be no greater than 8 kg.
Req 4.1.3-P	The height of the produce shall not exceed 40cm.
Req 4.1.4-P	The width of the product shall not exceed 70cm.
Req 4.1.5-P	The depth of the product shall not exceed 50cm.

Req 4.1.6-F	The device shall be waterproof and afford lightly impact.
Req 4.1.7-F	The device shall be opaque to occlude the interior components.
Req 4.1.8-F	The device shall contain a handle to provide users a portable function.

DoggyGo is designed to be a portable toy used for both indoors and outdoors. Therefore, we must consider the overall size and weight to achieve portability. In addition, the device should be durable to bear any impact and damage from pets.

4.2   Rotatable Base

Table 4.2: Rotatable Base

Req 4.2.1-C	The base shall be able to rotate at least ±60° both clockwise and counterclockwise horizontally about the geometric center of the launcher, in increments of 15°.
Req 4.2.2-P	The drive motor shall supply sufficient torque to overcome inertia of the all components of launcher part and achieve adequate acceleration.
Req 4.2.3-F	The angle of rotating shall be adjusted gradually and accurately.

All internal components and parts of ball launcher should be put on a rotatable base, so that users can manually change the horizontal launch angle. In order to achieve that, we will use a drive motor and gear set to rotate the base.

4.3   Ball Launcher

Table 4.3: Ball Launcher

Req 4.3.1-C	The torque of motor shall be able to shoot the ball to the maximum required distance of 9m at a vertical angle of 30°.
Req 4.3.2-P	The launcher vertical angle shall allow adjustments from +30° to +60° in 10° increments.
Req 4.3.3-P	The vertical angle of launching shall be adjusted gradually and accurately.
Req 4.3.4-P	The ball projectile shall be consistent and easily determined based on the configured parameters (angle/distance).
Req 4.3.5-F	The components used (motors, gears, springs etc.) shall operate effectively over a reasonable operational lifetime.

DoggyGo Inc.

4.4   Treat Dispenser

Table 4.4: Treat Dispenser

Req 4.4.1-C	The treat dispenser shall work in both automatic and manual mode.
Req 4.4.2-C	The dispenser shall dispense at least one treat each time.
Req 4.4.3-P	The dispenser shall be able to accept treats up to a maximum size of 3cm x 3cm x 3cm.
Req 4.4.4-P	The dispenser shall be able to dispense any shape of treats.
Req 4.4.6-F	The treats shall be easy to load into treat container.

5   Hardware Requirements

5.1   Sensors

Table 5.1: Sensors

Req 5.1.1-C	Two ultrasonic sensors shall detect distances up to 3 meters.
Req 5.1.2-C	One proximity sensor shall detect the ball in launcher pocket.
Req 5.1.3-C	Three proximity sensors shall detect the amount of balls contained in the launcher
Req 5.1.4-P	Ultrasonic sensor has minimum sensing distance of 0.1 meters and a detecting range up to 3 meters.
Req 5.1.5-P	Ultrasonic sensor shall have a resolution up to 5 mm.
Req 5.1.6-P	Proximity sensor shall have a resolution up to 1 mm.
Req 5.1.7-F	The ultrasonic sensor shall have a detection in range [0.1m - 3m] away from a dog as a safety area.

To ensure the safety of people and dogs, we will require two ultrasonic sensors and one passive proximity sensor to detect the presence of people and dogs as well as nearby surroundings efficiently. Before launching the ball, these sensors will detect any obstacles within 3 meters to ensure that the surroundings are clear before launching the ball. If there are dogs and people within the launcher truck, the launcher will automatically stop.

5.2 Buttons

Table 5.2: Buttons

Req 5.2.1-C	There shall be two buttons on DoggyGo, one (A) shall be used to turn on/off the power and one (B) shall be used to change the mode of operation (Auto or Manual) of DoggyGo.
Req 5.2.2-C	There shall be one remote to control the distance, angle, and treat/ball launch in manual mode of DoggyGo.
Req 5.2.3-P	The buttons on DoggyGo shall be highly visible and easily accessible for a end-user.

5.3 Motors & Gears

Table 5.3: Motors & Gears

Req 5.3.1-C	There shall be four gears to rotate the angle for semi-circular launcher pad both horizontally and vertically.
Req 5.3.2-C	The motors for semi-circular launcher pad shall control and rotate the orientation of two gears to adjust with a high accuracy to any desired angle.
Req 5.3.3-C	One motor shall release the treat when the returned ball is detected by proximity sensor.
Req 5.3.4-P	The circular pitches and the face width of driving gears should perfectly match those of the engaged gears.
Req 5.3.5-P	The angular displacement of the semi-circular launcher pad must be accurately determined based on input angles and launch strength.

5.4 Remote Controller

Table 5.4: Remote Controller on Hardware

Req 5.4.1-C	The remote shall be enclosed in a plastic enclosure weighing under 2 kilograms.
Req 5.4.2-C	The remote shall contain two sets of rocker switches to control the angle (vertical and horizontal) of the launcher along with a slider ON-OFF switch to turn the remote on or off.
Req 5.4.3-C	The remote will contain a switch to select the strength of the launched ball.

Req 5.4.4-C	The remote shall have two push buttons to fire the launcher and dispense treats.

6   Electrical Requirements

Electrical is a critical component in our system as it provides the necessary connections for power and data passthrough between the different components of the system. The following requirements below describe electrical requirements to ensure that our power delivery conforms to specifications and ensure that our wiring is efferently organized.

6.1   General

Table 6.1: Electrical General

Req 6.1.1-C	DoggyGo must be powered using a wall adapter.
Req 6.1.2-C	DoggyGo shall contain a USB-B port passthrough to allow diagnostics on the system controller.
Req 6.1.3-P	DoggyGo must be powered using a 12V DC battery.
Req 6.1.4-P	DoggyGo must be able to operate for a minimum of 30 minutes in automatic mode.

During our proof of concept and prototyping phase, we will be using in-wall power to allow us to develop the system without having to constantly recharge the battery which may cause an increase in our development time. To allow us to debug the system, we will have a USB port to connect our microcontroller to a computer to develop and debug any issues encountered during the development and prototyping phases. This debug port will be removed or hidden in the final product to avoid confusion for the end-user.

6.2   Power

Table 6.2: Power

Req 6.2.1-C	The power delivery system shall provide 12V DC at 3 Amps.
Req 6.2.2-P	The input voltage to the microcontroller must be between 3-12 V DC.
Req 6.2.3-P	The power delivery system must be rechargeable, providing a minimum of 4 watt-hours.

6.3   Remote Controller

Table 6.3: Remote Controller on Electrical

Req 6.3.1-C	The remote shall be powered using a battery which weighs under 50g (weight of a 9V battery or lighter).
Req 6.3.2-P	The remote must have a minimum transmission range of 3 feet from DoggyGo.
Req 6.3.3-P	The remote controller must be able to operate for a minimum of 1 hour.

6.4   Wiring

Table 6.4: Wiring

Req 6.4.1-C	All wiring shall be insulated using PVC insulation.
Req 6.4.2-P	The 12V DC power shall be distributed to different components on the system using a terminal block.
Req 6.4.2-F	Wiring shall be organized using braided sleeving and zip-ties.

7   Software Requirements

7.1   General

Table 7.1: Software General

Req 7.1.1-C	The system shall detect any obstacles that are located within 2 feet from the launcher.
Req 7.1.2-C	The system shall be running on a microcontroller compatible of accepting sensor inputs and outputs.
Req 7.1.3-P	DoggyGo must determine if any obstacles are in front of the launcher before launching the projectile.
Req 7.1.4-P	DoggyGo must use a hardware switch to switch between Automatic and Manual mode.
Req 7.1.5-P	DoggyGo shall have the ability to adjust the horizontal angle of the launcher at predetermined intervals using the remote.
Req 7.1.6-P	DoggyGo shall dispense treats when a ball is returned to the catcher or can

be manually dispensed using a button on the remote.

Req 7.1.7-P   DoggyGo shall issue a beep through a built-in speaker before launching the ball to ensure safety (after beeping for 3 seconds).

Req 7.1.8-P   DoggyGo shall open its treat dispenser for 3 seconds when a ball is returned to the catcher (in automatic mode) or when the user presses the treat dispenser button on the remote (in manual mode).

Req 7.1.9-P   DoggyGo shall illuminate an LED on the front of the system to indicate if the system is out of balls.

Req 7.1.10-P   DoggyGo Shall have a switch to determine if treats are dispensed in automatic mode.

Req 7.1.11-P   DoggyGo shall fire a subsequent ball after 5 seconds when the launched ball is returned to the catcher.

Req 7.1.12-F   The system must be able to detect hardware and software exceptions and handle them properly.

Req 7.1.13-F   The system must be handling system resources efficiently through the use of data structures.

The software will be responsible for handling all of the functions that are on DoggyGo. The main feature will be the ball launcher. The system will have the ability to operate in two modes: Automatic and Manual.

Automatic mode allows DoggyGo to operate automatically without any user interaction. Once the device is powered on, the device will setup using predefined parameters for the launcher angle, strength and direction and will launch a ball when the distance sensor has determined that the launcher projectile has no obstacles in front of it. When the ball is returned back into the catcher, the system automatically dispenses treats into a tray located on the side of DoggyGo based on the treat setting.

Manual mode, which can be enabled using a slider switch on DoggyGo, can be used when the user wants to have more control with the device. The ball will now only be fired when the user presses a button on the remote. The treat dispensing will be a similar mechanism where it will be manually activated using a button on the remote.

7.2   Remote Controller

Table 7.2: Remote Controller on Software

Req 7.2.1-P   There shall be two sets of "+" and "-" push buttons on remote to control the vertical and horizontal angle adjustments in increments of 15° and 30° respectively.

Req 7.2.2-P signals.	The remote will wirelessly transmit signals to the system using different IR

Req 7.2.3-F	The remote must illuminate a battery indicator LED to prompt the user if the remote is low on battery.

The remote controller will be used to allow control the system when in manual mode. The remote controller will allow the user to control the angle and strength of the launcher and as well as dispensing treats.

8   Engineering Standards

Following proper standards for both the design and integration process in development is a crucial aspect in producing a long lasting and maintainable product. The standards published by acclaimed organizations such as CSA And ISO will act as a guideline to the team at DoggyGo Inc. The construction and operation of DoggyGo shall comply with the following engineering standards.

8.1   Electrical & Mechanical

Table 8.1: Electrical & Mechanical Engineering Standards

Req 8.1.1-F	The drive motor shell comply the safety standards listed in CAN/CSA-C22.2, No.100-14 [1].
Req 8.1.2-F	The rechargeable power sources utilized in the operation of DoggyGo shall conform to the general standards stated by ANSI C 18.2M [2].
Req 8.1.3-F	During operation Doggy GO's components shall not surpass temperature values cited in NFPA (Fire) 70 standards [3].
Req 8.1.4-F	The ultrasonic detectors shall comply with the safety standards list in CAN/CSA-C22.2 No.61010-1-12 [4].
Req 8.1.5-F	The launcher build shall obey the rules given in CAN/ISO 8124-1:2018 [5].

8.2   Environmental

Table 8.2: Environmental Engineering Standards

Req 8.2.1-F	The development process of DoggyGo shall conform to CAN/CSA-ISO/TR14062-03 regarding consideration of environmental aspects during design and implementation [6].

9 Sustainability & Safety

9.1 Sustainability

Table 9.1: Sustainability

Req 9.1.1-P	DoggyGo shall rely on rechargeable power source when possible in place of consumables.
Req 9.1.2-P	The disassembling process of DoggyGo shall not cause any damage to individual components.
Req 9.1.3-P	The path of operation for DoggyGo shall be optimized to perform its task with minimal power consumption.

Cradle-to-cradle design is a biomimetic approach to the design of products and systems that models human industry on nature's processes viewing materials as nutrients circulating in healthy, safe metabolisms. The term itself is a play on the popular corporate phrase "Cradle to Grave," implying that the C2C model is sustainable and considerate of life and future generations.
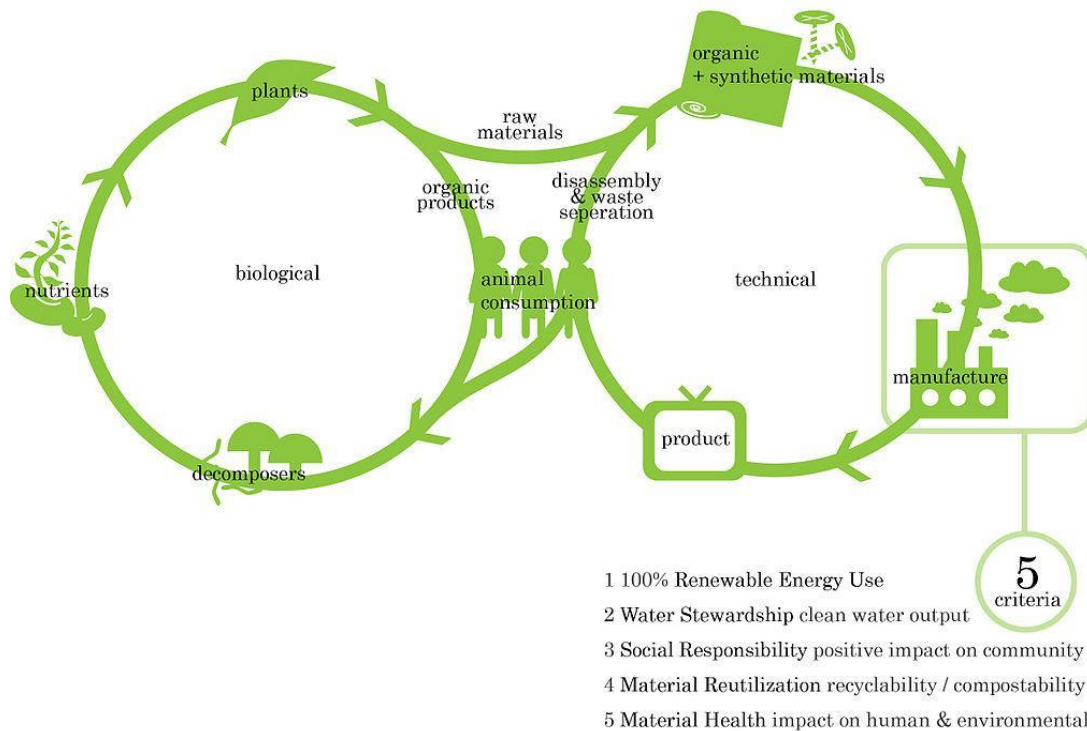

Figure 9.1: C2C Cycle [7]

DoggyGo aims to be an environmentally friendly product, so for both prototype and final product, we will comply to the C2C development as shown above.

9.1.1 Components

The product should involve a chamber for launching and a barrel for launch a ball. To minimize weight for portability, resin products (ABS/PBT Alloy) will be used as the main material, which has advantages below:

1. **Low Conductivity, Great Heat Resistance, High Corrosion Resistance and High Strength**

    ABS/PBT Alloy is widely implemented on motorcycle or vehicle covers, resulting in a safe and low-cost way to manufacture.

2. **Natural Source**

    ABS/PBT Alloy is from resin, which is environmentally friendly material.

3. **Lightweight and High Wear Resistance**

    As it is an animal toy, DoggyGo should be highly wearproof to be long lasting. DoggyGo should be also lightweight to allow owners to easily transport the device outdoors or indoors.

DoggyGo will also require metal for components such as motors, gears, or modules like speakers. All of these components and electrical devices will be reusable or safely recyclable.

9.1.2 Energy Consumption

The idea for the driven energy is the rechargeable battery. Considering the energy consumption, DoggyGo Inc will ensure the operation for the product will efficient to minimize the power draw of the battery and thus increasing its operation time.

9.2 Safety

Table 9.2: Safety Request

Req 9.2.1-P	The edges on DoggyGo shall be rounded to prevent injury to pets or operators.
Req 9.2.2-P	The product shall be able to sustain shaking or knocking without any damages to DoggyGo.
Req 9.2.3-P	The control panel (including power bottom, mode switcher etc.) shall have a cover to be protected.
Req 9.2.4-P	The treat box shall be pet-resistant to any damages.

Req 9.2.5-P	The end user shall be able view the contents of the container without opening the container itself.
Req 9.2.6-F	The system must shut down immediately automatically once the overheat or error is detected.
Req 9.2.7-F	The product shall be designed as waterproof to sustain for raining weather conditions or accidental liquid spills.
Req 9.2.8-F	The wire shall be hidden into the body of product to protect the product from any damages or electrical hazards.
Req 9.2.9-F	The area within the launching range shall be analyzed to launch the ball when the projectile path is free of obstacles.

DoggyGo will make sure that potential hazards shall be non-existent, from the product internally or from the outer enclosure shell of our system. Our prototype will be a compact design which will contain the highest possible protection mechanisms to ensure that our product is safe to use.

10   Conclusion

This document has introduced an architectural and functional reference for DoggyGo concept - the prerequisites for an automatic animal entertainment toy. This document aims to explain and specify all function requirements that shall be satisfied for our project design.

A brief summary of these requirements is displayed below:

1. **Mechanical Requirements**
   - The size of product will be restricted in a reasonable range and the product will be waterproof
   - The launching system will be set to allow unit step increments of angle change
   - The treat system will release treats when the ball has returned into the catcher (in automatic mode) or is manually activated using a remote (in manual mode)
2. **Hardware Requirements**
   - Sensors will detect whether the system contains excess balls, whether the ball is ready to be launched, and whether the surrounding environment is safe to launch the ball
   - The remote will be designed for manual mode where the user will be able to manually adjust the launcher parameters and manually dispense treats.
3. **Electrical Requirements**
   - The rechargeable power shall be implemented in our final product.
   - The wire should be neat and hidden from the outside using an opaque enclosure on DoggyGo.

4. **Software Requirements**
   - The system will work with sensor inputs and motor signals through a microcontroller
5. **Engineering Standards**
   - The mechanical, electrical, and environmental standards published by acclaimed organizations that the team will follow as a guideline throughout the project.
6. **Safety & Sustainability**
   - The design choices the team has made towards producing a sustainable product.
   - The safety concerns regarding DoggyGo and the planned solutions.

Going through these phases of development, this document will provide a reliable reference to satisfy all functional requirements at each stage, unless there are unexpected factors or circumstances that will appear and require additional attention during our development phases.

References

[1]   CSA Group, "CAN/CSA-C22.2, No.100-14-Motor and generators"

https://store.csagroup.org/ccrz__ProductDetails?viewState=DetailView&cartID=&sku=2424 409_bundle_rl&isCSRFlow=true&portalUser=&store=&cclcl=en_US, 2015, [Online; accessed 30-Jan-2019]

[2]   American National Standards Institute (ANSI), "ANSI C18.2M, Part 1-2013, American National Standard for Portable Rechargeable Cells and Batteries-General and Specifications,"

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[3]   National Fire Protection Association (NFPA), "NFPA (Fire) 70,"

https://www.techstreet.com/ieee/standards/nfpa-fire-70?product_id=1926856#jumps/, 2016, [Online; accessed 30-Jan-2019]

[4]   CSA Group, "CAN/CSA-C22.2 NO. 61010-1-12 (R2017) - Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements,"

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[5]   ISO, "CAN/ISO 8124-1:2018 – Safety of toys – Part 1: Safety aspects related to mechanical and physical properties"

https://store.csagroup.org/ccrz__ProductDetails?viewState=DetailView&cartID=&sku=iso_0 74477&isCSRFlow=true&portalUser=&store=&cclcl=en_US, 2018, [Online; accessed 30-Jan-2019]

[6]   CSA Group, "CAN/CSA-ISO/TR 14062-03 (R2013) - Environmental Management - Integrating Environmental Aspects into Product Design and Development,"

http://shop.csa.ca/en/canada/design-for-the-environment/cancsa-isotr-14062-03-r2013/invt/27018132003, 2003, [Online; accessed 30-Jan-2019]

[7]   By Zhiying.lim - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=21082299, [Online; accessed 30-Jan-2019]

Appendix A: Proof of Concept Test Plan

In this appendix, DoggyGo proof of concept (PoC) functionalities will be described in order to demonstrate our main functionalities of our Automated Animal Ball Launcher System to determine the overall feasibility of our project. The PoC requirements will be the main test plan we will use to verify the functionality of our system. Some examples of test plan method involve verification of debug messages that are obtained from the microcontroller to verify that our actions performed on the microcontroller correspond correctly to the actual action that were performed through visual inspection.

During our development process, we may run into issues that may extend our development time for our PoC. Therefore, we will prioritize the following requirements to ensure that we are able to display the key functionalities in our proof of concept prototype:

1. The base shall be able to rotate at least ±60° both clockwise and counterclockwise horizontally about the geometric center of the launcher, in increments of 15°.
2. Two ultrasonic sensors shall detect distances up to 3 meters.
3. Req 6.1.1-C   DoggyGo must be powered using a wall adapter.
4. The system shall detect any obstacles that are located within 2 feet from the launcher.

In addition to meeting the key requirements in DoggyGo, the PoC shall meet all our requirements that are labeled a C suffix. A reference of requirements is attached below:

Table A.1: PoC Requirements

High Level Requirements	Overall Performance	Req 3.2.1, Req 3.2.2, Req 3.2.3, Req 3.2.4
Physical and Mechanical Requirements	General	**Req 4.1.1**
	Rotatable Base	**Req 4.2.1**
	Ball Launcher	**Req 4.3.1**
	Treat Dispenser	**Req 4.4.1, Req 4.4.2**
Hardware Requirements	Sensors	**Req 5.1.1, Req 5.1.2, Req 5.1.3**
	Buttons	**Req 5.2.1, Req 5.2.2**
	Motors & Gears	**Req 5.3.1, Req 5.3.2, Req 5.3.3**
	Remote Controller	**Req 5.4.1, Req 5.4.2, Req 5.4.3**
Electrical Requirements	General	**Req 6.1.1, Req 6.1.2**
	Power	**Req 6.2.1**
	Remote Controller	**Req 6.3.1**
	Wiring	**Req 6.4.1**
Software Requirements	General	**Req 7.1.2**

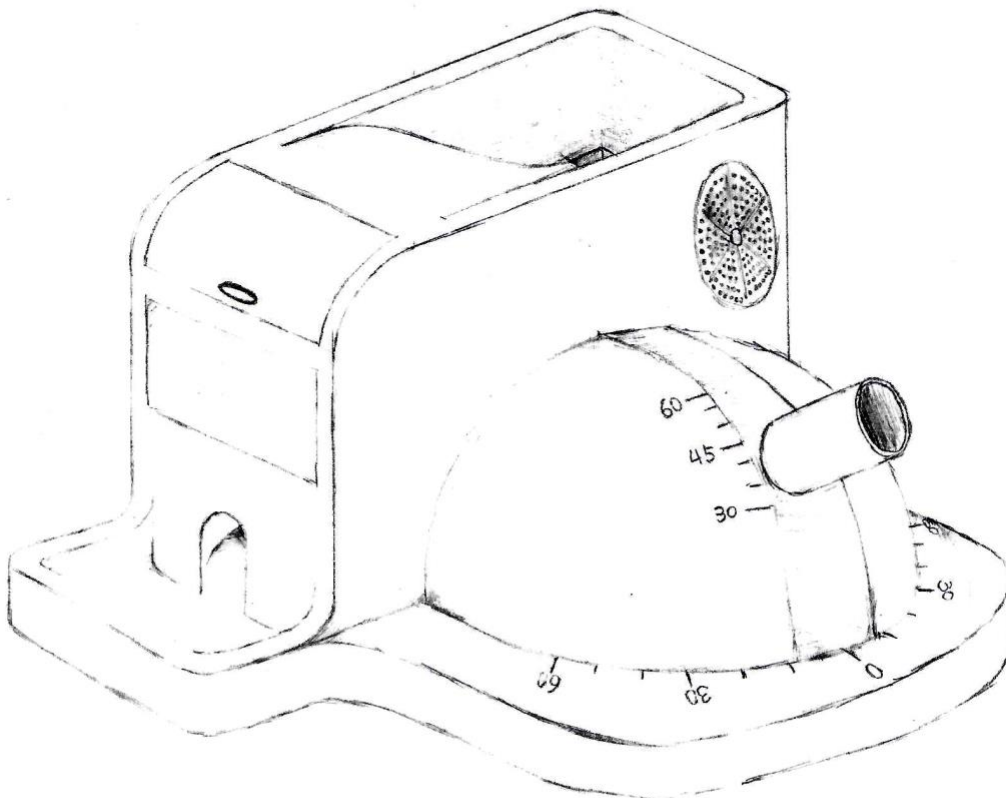# Appendix B: Overall Design Mockup

Figure B.1: Initial Mockup of DoggyGo
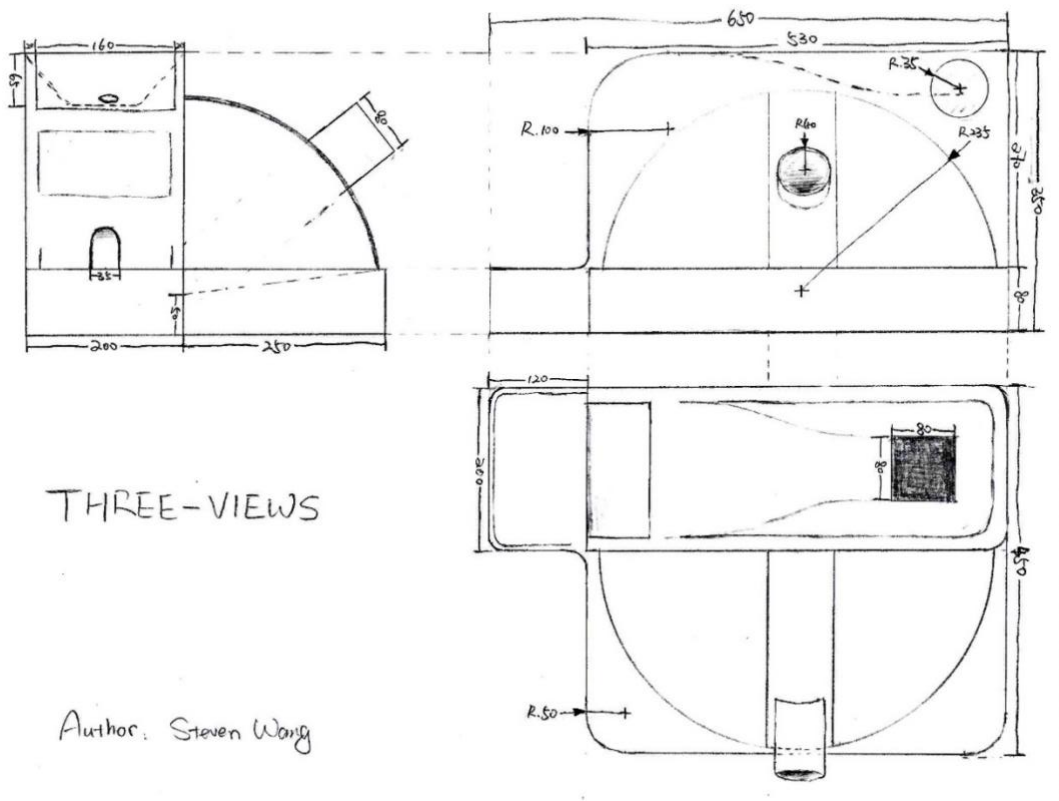
Appendix C: Three-Dimension Overview

Figure C.1: Initial 3-D View of DoggyGo
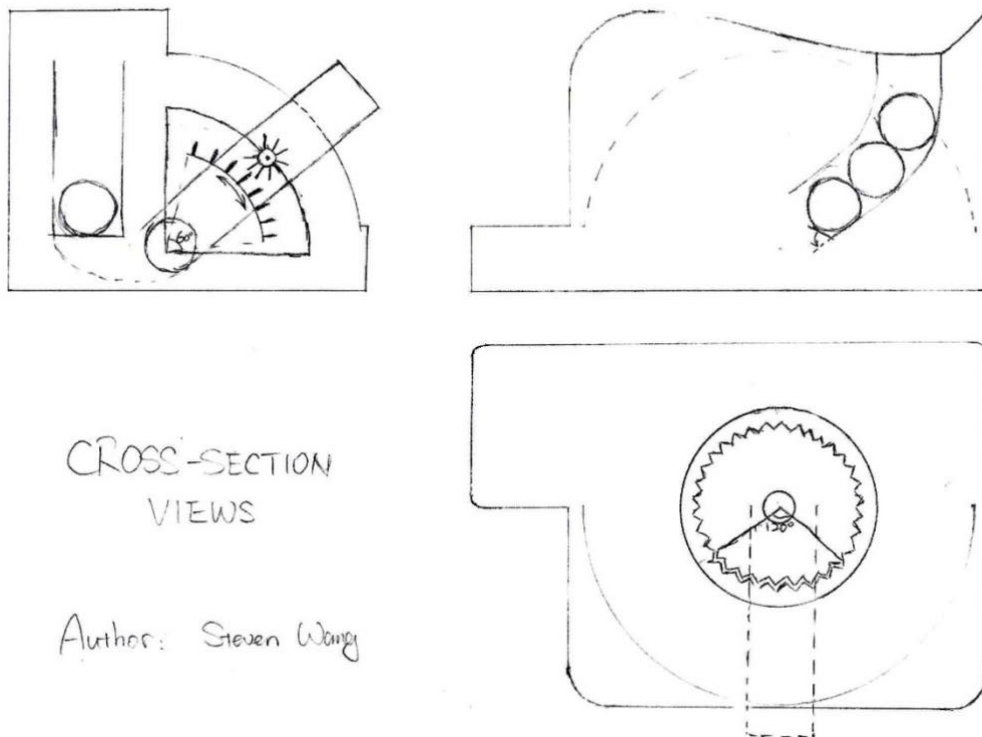
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Appendix D: Cross-Section View

Figure D.1: Initial Cross Section View Mockup of DoggyGo