



CANEAT

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May 31, 2018

Steve Whitmore
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Re: ENSC 405W Project Proposal for Caneat Inc.

Dear Mr. Whitmore:

The attached document provides a high-level outline for the development of our product, automated kitty litter box. This product, CANEAT, aims to provide a convenient and clean life for pets and hosts.

The purpose of this proposal is to outline our project scope and purpose, pushing out the benefits and risks. It will also provide an information of project scheduling and organization. Finally, it will give the introduction of our company and our brilliant team members.

CANEAT consists of 3 brilliant and compassionate senior engineering students: Kailun Liang, Wenjie Li, Zewen Wu. If you have any questions or concerns regarding proposal, please contact kailunl@sfu.ca.

Regards,

Kailun Liang

Enclose: Project Proposal for Caneat



CANEAT

Project Proposal

Automated Kitty Litter Box

“Make your life convenient and neat”

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Dr. Andrew Rawicz

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Executive summary

Cleaning up the waste for pets is a daily activity for breeders. Especially for cats, they have specified litter boxes to store their excrement. It is better to clean the box frequently, otherwise the stink smell will be left inside of the room. That will be perfect if someone or some devices can clean it periodically.

Our prototype, CANEAT, aims to automate the procedure in order to bring a more convenient lifestyle for breeders. The product will filter out the waste, and store them into a sealed container which can prevent the smell from leaking. This product is opened for all kinds of group such as people are disabled, busy, and someone travelled a lot.

The device will be assembled by a microcontroller, detecting sensor, power source, and some 3D-printed components. The prototype will be designed and constructed as a stable device which is strong enough to support all the materials.

Ultimately, our product will have the ability to scoop the waste, and clean the litter box for breeders automatically. The using method will be simple, and we may consider to develop an IOS/Android app to control it with more features.

CANEAT Inc. is made up of 3 highly motivated Engineering students that have comprehensive experience in hardware and software. We are going to work on the Capstone step by step, and try to accomplish all the ideal functions in the end.

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Glossary

Microcontroller A small computer on a single integrated circuit.

Van Petz The pet specialist in Vancouver. (Website: www.vanpetz.com)

Homogeneous Transformation Matrix A projective transformation of the projective

plane is a mapping $L : \mathbb{P}^2 \rightarrow \mathbb{P}^2$ defined as $\begin{pmatrix} u \\ v \\ w \end{pmatrix} \mapsto \begin{pmatrix} a & b & c \\ d & e & f \\ g & h & k \end{pmatrix} \begin{pmatrix} u \\ v \\ w \end{pmatrix} = \begin{pmatrix} au + bv + cw \\ du + ev + fw \\ gu + hv + kw \end{pmatrix}$, where $a, b, c, d, e, f, g, h, k \in \mathbb{R}$. The 3×3 matrix representing the mapping L of the projective plane is called a homogeneous transformation matrix.

Gantt Chart A Gantt chart provides a graphical illustration of a schedule that helps to plan, coordinate, and track specific tasks in a project.

Arduino Uno The Arduino UNO is a widely used open-source microcontroller board developed by Arduino.cc.

Weight Sensor A transducer that is used to create an electrical signal whose magnitude is directly proportional to the force being measured.

Distance Sensor Fast and accurate measurement, precise positioning and detection of a wide range of materials.

Adapter Charger A type of external power supply, often enclosed in a case similar to an AC plug.

PCB A printed circuit board (PCB) mechanically supports and electrically connects electronic or electrical components.

ESSS Engineering Science Student Society

SFU Simon Fraser University

ESSEF Engineering Science Student Endowment Fund

1. Introduction

According to the Latest Canadian Pet Population Figures Released [1] in 2017, from 2014 to 2016, cat and dog populations in Canada have risen. Household cats continued to outnumber dogs with 8.8 million in 2016, up from an estimated 7.0 million in 2014. Dogs increased from 6.4 million in 2014 to 7.6 million in 2016.

This huge amount of increasing in growth is even larger than the Canada population growth, which proves pets, especially cats, play a vital role in our lives. They are loyal companions and the pet ownership contributes to improved mental and physical well-being – it reduces stress [2]. Cats only occupy a portion of owners' lives, but the owners are the ones who share the whole period of lives with for the cats.

The objective of our project is to develop a device that can take care of the cats and keep them tidy when the owners are not at home, or when they are out of town for couple days. Also, it will provide the elderly owners an easier method to do the litter job. The feature function for the device will be cleaning the cat litter box automatically. The device will detect whether the litter box has been used by the cats, and send signals to inform the micro controller. The controller will have to decide automatically whether it is the time to clean up. In order to use the cat litter efficiently, the mechanism of the waste cleaner will be designed to filter it. The clean litter will be kept afterwards, and the device will get rid of the waste.

Several signal lights will be attached on the device to give information to users under different circumstances that have to be solved manually. For example, waste bag is full, cat litter is not enough for the next use, and at the time when the device is stop working. When one of the situation happens, the device will make sounds to let users know. All of these lights and alerts will be connected to a mobile app to provide better announcements, and it will collect data such as cat litter efficiency.

This document is a proposal providing an overview of our projects, outlining the user scope, studying the trending market, company details, sources of funding, and project planning. At the end of the proposal, we will show you the detailed cost consideration,

and its alternate method. Gantt chart and the milestones timeline show an ideal schedule, and we will work in this direction as much as possible.

2. Project Overview

This section will outline the overall high level system design and overview of our product. We will also discuss the scope of the project and the requirements and deliverables that are to be produced. To finish off it will outline the risks that may be presents as well as the benefits that the successful completion of this project will provide.

2.1 Scope

The purpose of CANEAT is to provide an easy and convenient device to assist the cat breeders who are disabled, elderly, busy, and lazy to clean up after cats using the litter box. The goal of our project is to design and create a product that is both affordable as well as easy to use to help those kind of breeders to enjoy more convenient lives with their cats. To accomplish this, we establish the main requirements of our device, which includes:

- Detecting whether the cats are inside or outside of the litter box
- Checking where there is any waste produced
- Filtering out the waste after separating them from the litter
- Checking whether the litter box is lack of litter or the waste bag is full
- Using coloured light to indicate different status
- Reporting to users when the device is in an erring process

The above outlines the main functions of our device but if we have sufficient time, we plan to include some other features such as:

- Prototype protecting cage
- Accompanying with an IOS/Android application
- Litter autofill appliance

The detailed information for our project will also be posted on a company website with product supports. In addition, the actually cost will be minimized, and much less than the initial cost if we assuming there is a large scale production is planned.

2.2 Risks

This section discusses the possible risks associated with the product during the period we are designing, prototyping, and finalizing it. It will also point out some potential risks while cats and breeders are using it. The risks include: unable to achieve the goal on time, unpredictable costs, mechanical issues, and uncertain damage from cats.

Unable to Finalize

This should be a common risk for many projects. Especially for a new oriented device, to design and develop each single function costs time for a team to do study and research. In addition, at the stage of integrating, more problems and bugs will need to be solved which is a major reason for postponing finalization. The best method to mitigate the delay is always accomplish every steps ahead of schedule.

Unpredictable Costs

Due to CANEAT will be assembled with 3D-printed components, the material cost is a unpredictable factor. The servo motors' cost which are used to support the prototype are also unpredictable since the motors' price range for different power is huge. Therefore, the table of cost estimation shows the maximize possible cost.

Mechanical Issues

In order to filter the waste from the cat litter properly, the structure of the device must be stable enough to support large amount of litter. The motors need to be powerful enough as well to move around the waste scoop among the litter. Since cat litter is tiny, the mechanical part has to be separated from the litter completely. Otherwise, the mechanism will easily stuck and stop working.

Uncertain Damage From the Cats

If the product is used by a kitten, it will get used to use it, but if the adult cats use CANEAT someday instead of using the original litter box, they may do not like it, and even try to damage it since it is something strange. Therefore, it is necessary to attach some protections.

2.3 Benefits

Life Efficiency

Although breeders love their cats, they may be tired of cleaning the waste someday. Now it is the time for CANEAT to demonstrate their ability! No matter the breeders are disabled, busy or tired of the day, they can just leave the litter box alone without the stinky smell, and spend time with their lovely cats. Ultimately, the product creates a more convenient lifestyle.

Health and Safety

To ensure there is no health issue that is harmful to the breeders or cats, the material which assembles the device will be followed the material standards strictly. To ensure it is a safe device, the power source will be under controlled, and all wires will be banded properly.

Reliability and Quality of Service

Our product aims to provide a consistent, high-quality cats waste cleaner. Detailed online instruction is posted on our website, and we welcome any kinds of suggestion and questions.

3. Market

3.1 Market Analysis

According to GfK (Growth from Knowledge) survey, 61% of Canadians own at least a pet. 35% of Canadians have cats (compared to 23% internationally), which is slightly greater than the dog ownership percentage [3]. In total, around 8.8 million of cats are bred in Canadian families. [4] Therefore, it can be derived that, currently, more and more families have more than one cat at home. Spending on pets and pet food in Canadian households rang in at CAD 4.1 billion in 2015, according to Statistics Canada. [5] However, in terms of litter box, we have sent out surveys, with the help of the local pet store Van Petz, regarding the popularity of automatic litter box among cats breeders to analyse if automatic litter box is possible take up more market share in the future. We have collected 156 feedbacks in a week. Most of people are using standard litter box

(153/156). To to specific, 15 of them think scooping the waste is a way to be closer to their pets' lives. 54 people said the price of the automatic litter box is much more expensive compared to the standard one. The rest of breeders are hesitated on the reliability of the automatic product, On the other hand, people who have used automatic litter box, in general, are satisfied with this investment. By counting the number of reviews to the most popular automatic litter box, PAL17-10786 produced by PetSafe, on Amazon, over the last 12 years (2006 ~ 2018), the volume of sales can be summarized as the figure below. It is obvious that the demand of the product is increasing. In 2007, there is only 12 reviews. 11 years later (2018), in May, 46 feedbacks have been left in a single month, which is 3.83 times of that in the entire year (2007). From 2017, the market share of the automatic litter box tends to be stabilized. In March, April and May, 2018, 50, 45 and 46 feedbacks have been left respectively. Overall, the automatic litter box has potential to equally share the market in the future.



Figure 3.1 Reviews of PAL17-10786 on Amazon

There are several reasons resulting in an increasing demand of the automated litter box. First of all, no matter how much you love your pets, taking care of their litter can hardly consider as a pleasant job, especially for the elder. It takes time, needs a bit strength and has to be patient. Moreover, when you have a close touch with their urine and excrement, even if they have already been purified by the cat litter, the litter gives off a pungent smell. Additionally, in the case which breeders leave home several days for business or vacation and their cats have to stay at home alone, probably, as a result, the litter box can not be cleaned up on time. Consequently, cats will not be willing to use the litter box and

they are going to pee or poop wherever they prefer. Therefore, in order to resolve these troubles, using automated litter box is always a better choice, compared to manual work.

However, some others factors may have impacts on the promotion of it. The first concern is, as for breeders, that whether the product is reliable and meets the expectation, which can be classified into several points. The automated litter box should be proved that it can effectively filtered out the excrement. Also, the cat litter refilling function should be activated after the cleaning progress has been terminated, which should be tested to check its validity. Once the garbage bin has been detected as full, the litter box should be turned to sleep mode and breeders should be notified. Last but not least, the product will not arouse any safety risks for cats. Addition to the reliabilities, currently, the price of product is much higher than the standard type. Regarding this, not all breeders are willing to pay extra money for it. It is the most direct factor affecting the market.

Overall, even though the automated litter box is not the most indispensable product for breeders, it shall be a valuable investment since the we are confident that our designed product is much more reliable and the price is affordable for most of intended customers.

3.2 Competitions

Currently, several companies have developed their own automatic litter box and many of products are available on Amazon. They are designed to be operated by different software controlling system, although some of them perform similarly. In order to efficiently scoop the waste in the litter box, the cleaning cycle is realized by different mechanisms. The price for automated little box ranges from CAD 104.97 to CAD 598.67 plus tax and delivery fee.

3.2.1 LitterMaid



Figure 3.2 LitterMaid LM680C

As it is shown in Figure 3.1, LitterMaid LM680C the cheapest automated litter box available on Amazon. It can automatically scoop waste after the cat uses the little box controlled by an adjustable program. The algorithm can be summarized in the following flow chart (Figure 3.2). After each cleaning cycle, the sleeping time of the automated progress is subjected to be adjusted.

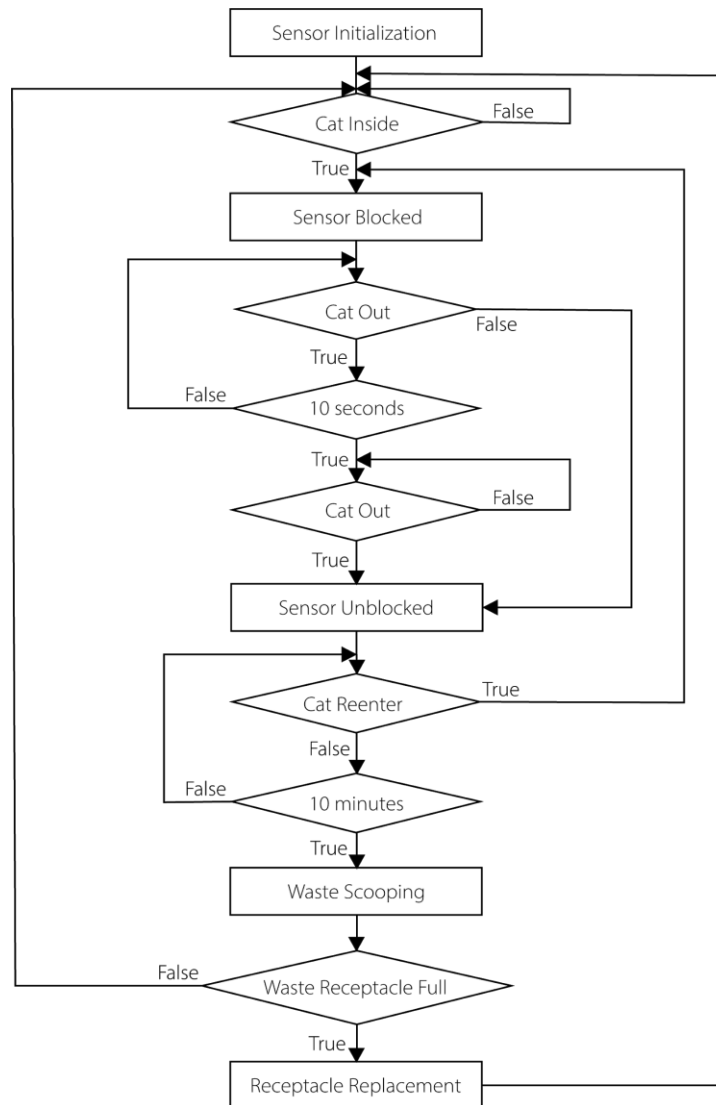


Figure 3.3 Controlling Algorithm of LM680C

As one of competitors, there are several advantages which may help this product stand out. The producer LitterMaid is the company, which has been founded over 30 years, concentrates on the design and production of litter box. Considering LitterMaid has taken over a decade to innovate its littlebox, their technology should be mature and reliable, from customers' points of view. Also, after researching the controlling algorithm developed by the company, there is no safety risk for pets and breeders. Regardless of the essential mechanism developed to scoop the waste, it is logical and effective. It can be considered as a reliable product in terms of software development. Side designs, such as carbon filter refills, can keep the litter smells gentle and reduce waste receptacle odor. For customers who would like to personally enjoy the convenience generated by automation, the price of the product is reasonable. On Amazon, 1028 customers write reviews. Among them, 53% of customers think it is a satisfactory product (3 stars or

more). By going over positive reviews, breeders are satisfied with the easy setup of the litter box. Practically, it can efficiently clean up the litter box with the automated cleaning rack.

On the other hand, the low price can reflect that cost of product development might be lower than similar products in the market, which means the litter box may not perform ideally. On Amazon, 47% of customers do think this product does not meet their expectation. Some customers complain that it is noisy when it is scooping the waste. The noise lasts for about 33 seconds. Moreover, the designed waste receptacle is so small that it has to be replaced after a single cleaning progress. Related to its controlling algorithm, even if the receptacle is full, its work is not going to be terminated, which means the waste are not going to be scooped out properly. Referring to my experience, the litter box is better to have a lid, which creates a more private room for cats and can effectively eliminate odors.

Apart from the market research depending on the information on Amazon, LM680C is also available on Taobao, the biggest Chinese online shopping website. Recently, 253 products have been sold. Several customers reviewed that the space of the litter box not large enough, which results in a consequence that the cat may pee or poop outside the cleaning area.

3.2.2 PetSafe

The most popular automatic litter box online is PAL17-10786 produced by PetSafe (CAD 148).



Figure 3.4 PAL17-10786

Different from LM680C, PAL17 has a sensorless controlling system. The litter box is cleaned once an hour no matter if it is occupied. In terms of the scooping mechanism,

instead of using a linear transformed rack, the base of it is rotational transformed around the centre of the box. Therefore, as one of its advantages, it does not require scooping of litters. Referring to the matrix transformation of robotics (Figure 3.4), at current frame, with respect to previous frame, the homogeneous transformation matrix can be calculated

as
$$R_z(\theta) = \begin{bmatrix} \cos \theta & -\sin \theta & 0 \\ \sin \theta & \cos \theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$
. In this case, the angular velocity is approximately 5 degree per second. During this time, waste is sifted out and carried up, with the help of the conveyor belt into the waste bin. Compared to LM680C, it has a relatively larger volume of waste receptacle. However, in practical, the salable area is smaller. Therefore, especially for big cats, they feel less comfortable excreting waste.

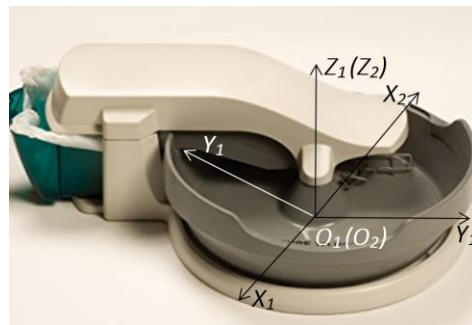


Figure 3.5 Reference Coordinates

On Amazon, 2548 customers have written reviews based on its functionality. 61% of them are satisfied with PAL17, which is 8% more than that of LM680C. Most of them are impressed by its reliability. Also, they think the space is sufficient for cats when they are about to poop or pee. However, this product is not flawless. Since the waste bin is not closed, even if the waste can be removed from the litter box, odors can not be reduced as long as the waste bin is not replaced. Initially, it is not noisy. Several weeks later, the annoying noise will be caused by the conveyor belt. Moreover, the extra work will be loaded to breeders, because the litter is easy to be shaved out by the cat. The main issue of this product is that the motor of the base which is USD 14.95 has to be replaced frequently. Overall, it is evaluated to be 3.2 out of 5, which is better than the one produced by LitterMaid (2.8 out of 5).

3.2.3 Litter Robot

The top rated automatic litter box is Litter-Robot III Open Air Automatic Self-Cleaning Litter Box. It is CAD 598.67, which is the most expensive one. In terms of its appearance, it is extremely fashion.



Figure 3.6 Litter-Robot III

The controlling algorithm is similar to that applied to LitterMaid. However, the cleaning cycle will be activated 7 minutes after the cat used the litter box. Compared to two litter boxes introduced above, the cleaning mechanism of Litter-Robot III is totally different and less time-consuming. Specifically, as the globe slowly rotates, the patented sifting system separates the clean litter from the clumps, and drops the waste into a carbon-filtered drawer in the base. The globe returns to the home position, leaving a clean, level bed of litter for the next use.

Although it is expensive, on Amazon, it achieves an excellent customer feedback, which is 4.6 out of 5. On Google and Yotpo, in total, there are 1308 reviews, 85% of customers evaluated it to be a 5 star automatic litter box.

4. Company Detail

We are CANEAT Inc, a company design product for pets. CANEAT Inc was found in 2018 with 3 engineering students at Simon Fraser University. Our first product, CANEAT Inc, is expected to be accomplished in 2018 August.

4.1 Introduction of Company

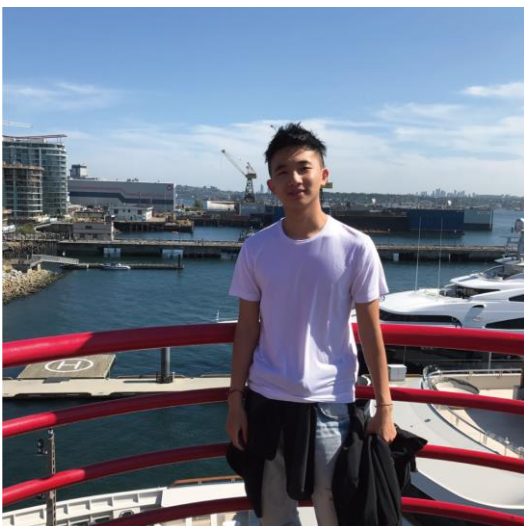
The name of our company is called CANEAT, which is the abbreviation of Cat Neat. In addition, the product's name is same as our company name. The reason why the product name is called Cat Neat is because the function of product is automatic cleaning cat's excrement, which will give cat a clean and comfortable environment. Nevertheless, this product brings not only the cozy atmosphere to pet but also a convenient life to host. In addition, hosts can play with their kitty while they are working in their office or studying at school.



Figure 4.1.1 : Logo of Caneat

The figure above is the logo of our company. The design idea of this logo is came from the cat eyes. Our company designed and made the product for cats, so there is a shadow of cat in the eye of cat.

4.2 Team



Kailun Liang (CEO)

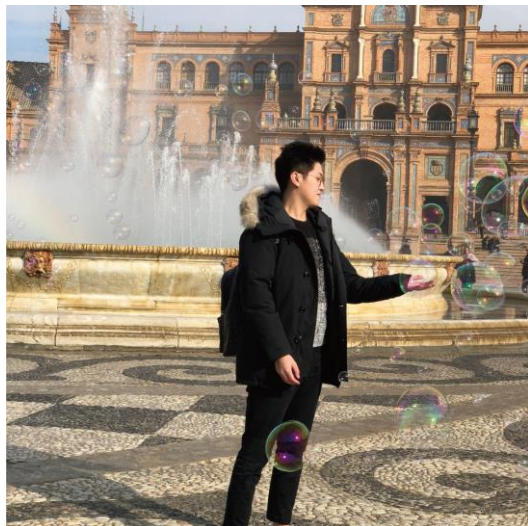
I am a 5th year System Engineering student. I have experience working with the website design and programming, and a personal project with magnetic encoder speedometer. I have a wide variety of interest but I primarily focus on mechanical project and trading. I

hope my background knowledge in marketing experience and system engineering can help to make this product perfect and successful.



Wenjie Li (CTO)

I am a 5th year Electronic Engineering student. I have experience in analog and digital circuit design, and programming language such as C/C++ and Python. Also, I have some Arduino experience during my research co-op. I wish these skills can contribute well to our Capstone project.



Zewen Wu (CFO)

I am a 4th year Systems Engineering student. Currently, I am working on my undergraduate thesis towards the development of People-following Drip Stand, which is supervised by Prof. Shahram Payandeh. Personally, I am interested in technologies related to Robotics, Artificial Intelligent and Image Processing. I am confident that my integrated knowledge can be helpful to our project.

5. Project Plan

In the figure below shows the Gantt chart of our project. This project is combined with two, four-month phase. The first phase will be designed the requirements and concept of product in software and the documentation. The second four months are assembled and

created the prototype. In addition, the first phase is separated into several small parts, which is shown in the second figure below.

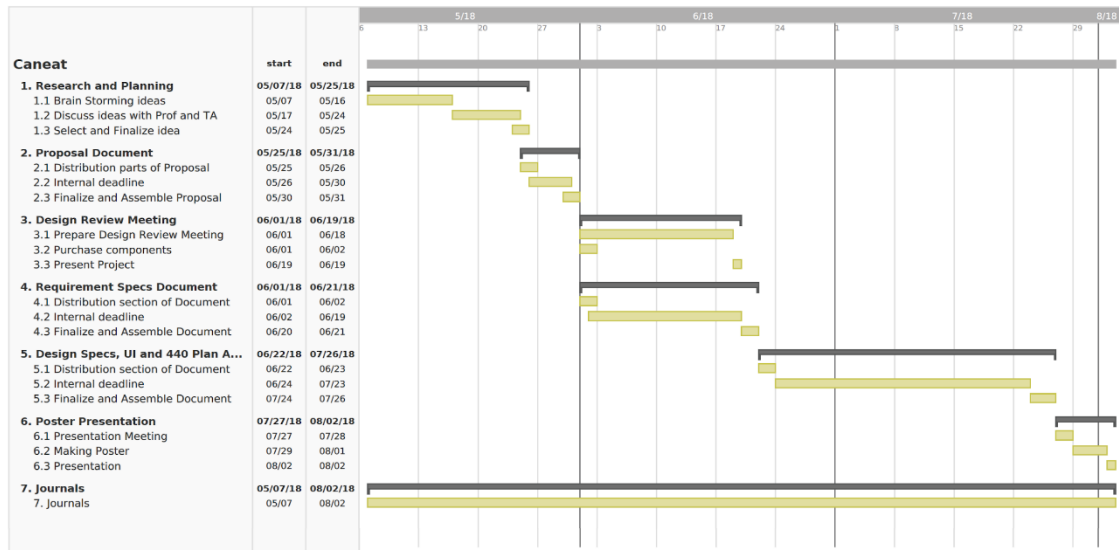


Figure 5.1 : Gantt Chart of First Phase of Caneat [6]

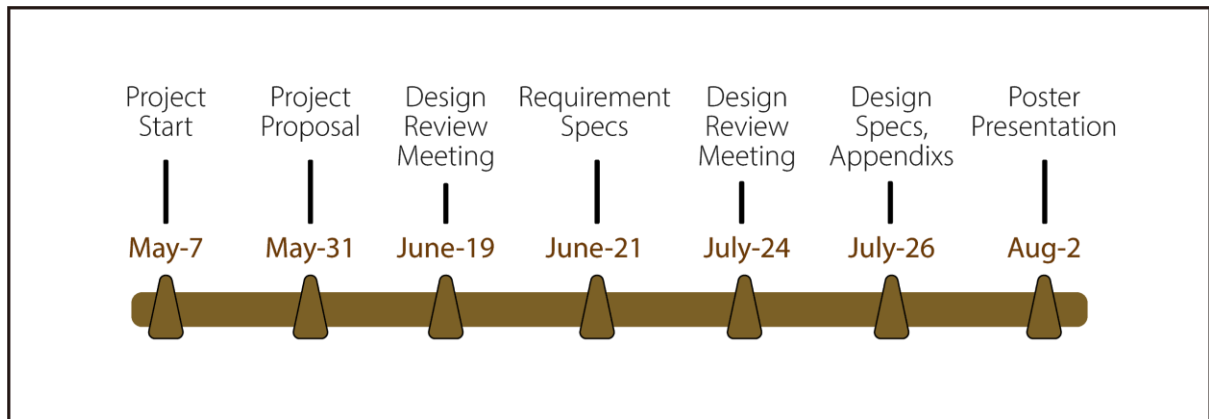


Figure 5.2 : Milestone Timelines of First Phase of Caneat

6. Cost Consideration

6.1 Estimate of Cost

The first table below is the initial cost consideration of prototype, and the second table is the cost of our final product.

Device	Description	Cost (CAD)
Litter box	Litter box	\$20
Litter	Litter	\$18
Arduino Uno	Arduino Uno	\$40
Weight Sensor	Detect the excrement & cat	\$10
Arducam CMOS Sensor	Camera	\$69
Distance Sensor	Detect the object in box	\$10.5
9V, 1A Adapter Charger	Power source	\$4.07
Miscellaneous Electrical Components	Motor/ Resistor/ Capacitor/ Opamps/ MOSFETs/ Breadboard/ Adapter,etc	\$175
Mechanical & Structural Components	3D Printer / Aluminium	\$150
Shipping	Cost of purchase	\$30
Tax	12 %	\$54.74
Total		\$510.91

Table 6.1 : Cost Consideration of Prototype

There are some differences between the final product and prototype. For prototype, we will reduce the size of product, and testing all the functions on arduino and breadboard. Some parts of design, litter filter, will be made by 3D printer, because 3D printer object can perfectly fit the size of our design. For the final product, we will apply more components that made by 3D printer, and we will create the product as professional as we can, which can directly sell in the industrial. In addition, some components will be order from China, since the price are much lower than Canada. However, it has the risk that

shipping delay or lost while order item from other country, so we make two plans for every item. This offers the product can be completed on time perfectly.

Device	Description	Cost (CAD)
Litter box	Litter box	\$20
Litter	Litter	\$18
Arduino Uno	Arduino Uno	\$40
Weight Sensor	Detect the excrement & cat	\$10
Arducam CMOS Sensor	Camera	\$69
Distance Sensor	Detect the object in box	\$10.5
9V, 1A Adapter Charger	Power source	\$4.07
PCB	PCB Manufacturing by CM	\$50
Miscellaneous Electrical Components	Motor/ Resistor/ Capacitor/ Opamps/ MOSFETs/ Breadboard/ Adapter,etc	\$175
Mechanical & Structural Components	3D Printer / Aluminium	\$100
Shipping	Cost of purchase	\$20
Tax	12 %	\$61.99
Total		\$578.56

Table 6.2 : Cost Consideration of Final Product

6.2 Funding Resource

6.2.1 Engineering Science Student Endowment Fund

Engineering Science Student Endowment Fund (ESSEF) is operated by Simon Fraser University (SFU) Engineering Science Student Society (ESSS) [13]. The purpose of

ESSEF is to support cost of innovative project made by SFU undergraduate engineers.

The project can be separated into 1 of 4 categories [15].

- Category A - Competition
- Category B - Entrepreneurial
- Category C - Class
- Category D - Miscellaneous

We are interested in Category B “Entrepreneurial” and Category C ”Class”. Our product meets the criteria of Category B and Category C, so we expected that CANEAT will be supported by ESSEF. We will apply for this fund next semester, second phase.

6.2.2 Wighton Engineering Development Fund

Wighton Engineering Development Fund is administered by Dr. Andrew H. Rawicz. The project will be funded by competitive basis, and we need to submit the proposal of the product [14]. We will apply for the fund next semester as well.

6.2.3 Personal Fund

For personal funding, if all the funding resources can not cover the cost of our product, then we will operate the personal funding for \$200 per team member. The final product will spend around \$600 to be completed, and there are three members in our group. To divide the cost, every team member will contribute \$200 for this project.

7. Conclusion

As cat breeders, they will be tired of cleaning the waste sometime, or too busy to clean it on time. Now the automated cat litter box brings you a more convenient method to deal with your pets instead of doing it manually. In addition, there is no more need to worry that the waste will continue to stink the room after a busy day after school or work since CANEAT will handle this for you.

To accomplish this this task, CANEAT will utilize a micro-controller as a core to control our unique mechanical design. The mechanism will include some 3D-printed components and several servo motors to separate the waste from the litter then filter it out. In order to

detect occupancy of the litter box, some sensor such as weight sensor and distance sensor will be attached in order to achieve more precise results.

The members of CANEAT are excited to generate this topic, and chose it as the a practical Capstone project. We are looking forward to write a more detailed design specification, and finalize the product soon.

We would like to thank Steve Whitmore and Dr. Andrew Rawicz for giving us advice on collaboration such as team dynamics, leadership, conflict resolution, and time management, and providing valuable suggestions on our topic which is a significant landmark through our undergraduate career.

Reference

[1]"Companion Animals", *Cahi-icsa.ca*, 2018. [Online]. Available: <https://www.cahi-icsa.ca/companion-animals>. [Accessed: 29- May- 2018].

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[6]"Online Gantt Chart Software | TeamGantt", *Teamgantt.com*, 2018. [Online]. Available: <https://www.teamgantt.com/>. [Accessed: 29- May- 2018].

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