



March 28, 2019

Dr. Craig Scratchley  
School of Engineering Science  
Simon Fraser University  
Burnaby, BC, V5A 1S6

Re: ENSC 405W/440 Design Specification for a Cat Health Monitor

Dear Dr. Scratchley,

The attached document is a proposal for our product, Cat Health Monitor, which is to be developed by our company 9 Lives. The requirements and design have already been specified in separate documents. Our objective is to produce a litter box that is capable of reporting on various metrics of a cat's health to the owner and their veterinarian. The information will help the owner know when their cat isn't feeling well, even though there may not be any obvious signs. To complete this product, we are required to design a hardware and software system and integrate them effectively.

The goal of this proposal is to provide an overview of our product and outline our plan for the realization of the product. The document will provide information on the scope of our project; possible risks and benefits of the product; a market analysis to see what the current competition is for the product; an estimate of costs for the fabrication of our product; and a schedule to outline deadlines for when project milestones should be completed.

We appreciate you taking the time to review our proposal for our Cat Health Monitor product. If you have any questions, please do not hesitate to contact Gary Atwal, our Chief Communications Officer, by email ([gatwal@sfu.ca](mailto:gatwal@sfu.ca)) or by phone (604-908-1456).

Sincerely,

Hakeem Wewala  
Chief Information Officer  
9 Lives

Enclosed: Design Specification for a Cat Health Monitor



## Project Proposal – Cat Health Monitor

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## Executive Summary

Cats are independent pets and because of this, it is not always easy for a cat owner to know if their pet is not feeling well. Cat owners usually only notice that there is a problem with their cat when they are displaying clear symptoms that are easily identifiable. It would be helpful to cat owners and veterinarians everywhere if there was a device to help notify owners and their veterinarians when there was an issue with a cat, even though the owner may think everything is okay.

Our product, Cat Health Monitor will provide cat owners and their veterinarians with information about a cat's health through its bathroom habits. Our product will be a surface upon which the cat's litter box is placed, and the built-in weight sensors and software will capture information namely how frequently the cat goes in the litter box and what the cat's weight is when it's in the litter box (so that the cat's weight can be trended over time).

As stated above, our surface will contain a weight sensing circuit within it that is composed of four strain gauges. The analog signal output from the circuit will be converted to digital through the use of an Analog-to-Digital Converter (ADC). The digital signal will be fed into an Arduino where the software computations will take place.

9 Lives is composed of 6 aspiring engineers who are committed to delivering a quality product that anyone can feel safe using in their home. Our company's goal is to help cat owners be aware when something is not right with their cat so that they can get the treatment their cat needs before it is too late. Our product will not only save cat owners' money by giving them advanced notice on issues with their cat that may have gone unnoticed for weeks, but it will also allow the owner to be at ease knowing that their cat's digestive system is functioning okay.



## Revision Record

| Revision # | Description     | Revised By   | Date           |
|------------|-----------------|--|----------------|
| 1.0        | Initial Release | Gary Atwal,<br>Harinderpal<br>Khakh, Brandon<br>Shen, Gabe<br>Teeger, Hakeem<br>Wewala and<br>Timothy Yu | March 28, 2019 |



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## Glossary

| <b>Term</b> | <b>Definition</b>       |
|-------------|-------------------------|
| AI          | Artificial Intelligence |
| C           | Proof-of-Concept        |
| CAD         | Canadian Currency       |
| CW          | Calendar Week           |
| F           | Final Product           |
| HW          | Hardware                |
| N/A         | Not Available           |
| P           | Prototype               |
| SW          | Software                |
| USD         | United States Currency  |



## 1.0 Introduction

Despite all the advances in medical treatments for animals, other than regular veterinarian checkups, the only way for a pet owner to know there is something wrong with their pet's health is to observe symptoms and then notify their veterinarian. Pet owners will usually only seek care for their pets once their symptoms are clearly presented through their appearance and behaviour. The problem arises when the symptoms of the pet's illness are not immediately obvious to the average pet owner. Unfortunately, this problem can cause owners to take their pets to the veterinarians after their illness has progressed further in which case the cost to treat the pet may be greater, the impact on the pet's health may be greater, or worse, it may be too late [1]. Pre-emptively avoiding certain serious health problems in animals that don't have clear visible signs to humans would be greatly beneficial to owners, veterinarians, and pets alike.

The Cat Health Monitor is a surface with built-in weight sensors and an insertable pH sensor, that can be placed underneath an owner's current litter box as opposed to the product being a whole new litter box, resulting in a more economical and user-friendly product. We aim to provide accurate real time information on important parameters regarding a cat's behaviour. This will allow the owners of cats and veterinarians to monitor a cat's health in a quick easy way so they can provide better care for the cats and save money on otherwise expensive medical bills.

This proposal will provide an overview of our product and outline how we plan to realize our product through detailed research, company and project planning and cost analysis. Section 2.0 will provide insight into potential benefits and risks involved in the project. In Section 3.0, we will detail the market for our product and the current competition. Our company, along with the expertise of our team will be presented in Section 4.0. Section 5.0 provides a schedule for which each stage of the project will be completed. Finally, Section 6.0 includes a realistic estimate of the cost for each component and suggests potential funding sources

### 1.1 Background

Many aspects of any animal's health, particularly their digestive health, can be measured by their bathroom habits. Our goal is to design a device that will provide consistent and reliable information to the owner about a cat's health by capturing the cat's duration and frequency of use of the litter box, the cat's weight and pH of the cat's waste over time. This data can be examined for any early indicators of illness and pre-emptively warn users. For example, frequent attempts at urination may be linked to kidney stones or blockage and if there is blood in the urine it may be linked to a more life-threatening condition, feline interstitial cystitis [2].

Although this technology would be beneficial to all animals, our product is specifically designed for pet cats. Because cats are independent and do not require much supervision, their symptoms of illness may go unnoticed. Many owners are left with an unexpected death to their cats that may have been preventable through basic monitoring of the cat's health. According to a study by Olsen and Allen [3] on 1000 cats over 10 years, 79 cats died suddenly and unexpectedly [3].

### 1.2 Scope

The scope of this Capstone project includes the research, design, assembly and testing of a Cat Health Monitor. The product will be able to provide owners and veterinarians with data on the cat by:

1. Accurately weighing the cat when it is in the litter box.
2. Reliably sending information related to the data collected to user(s).

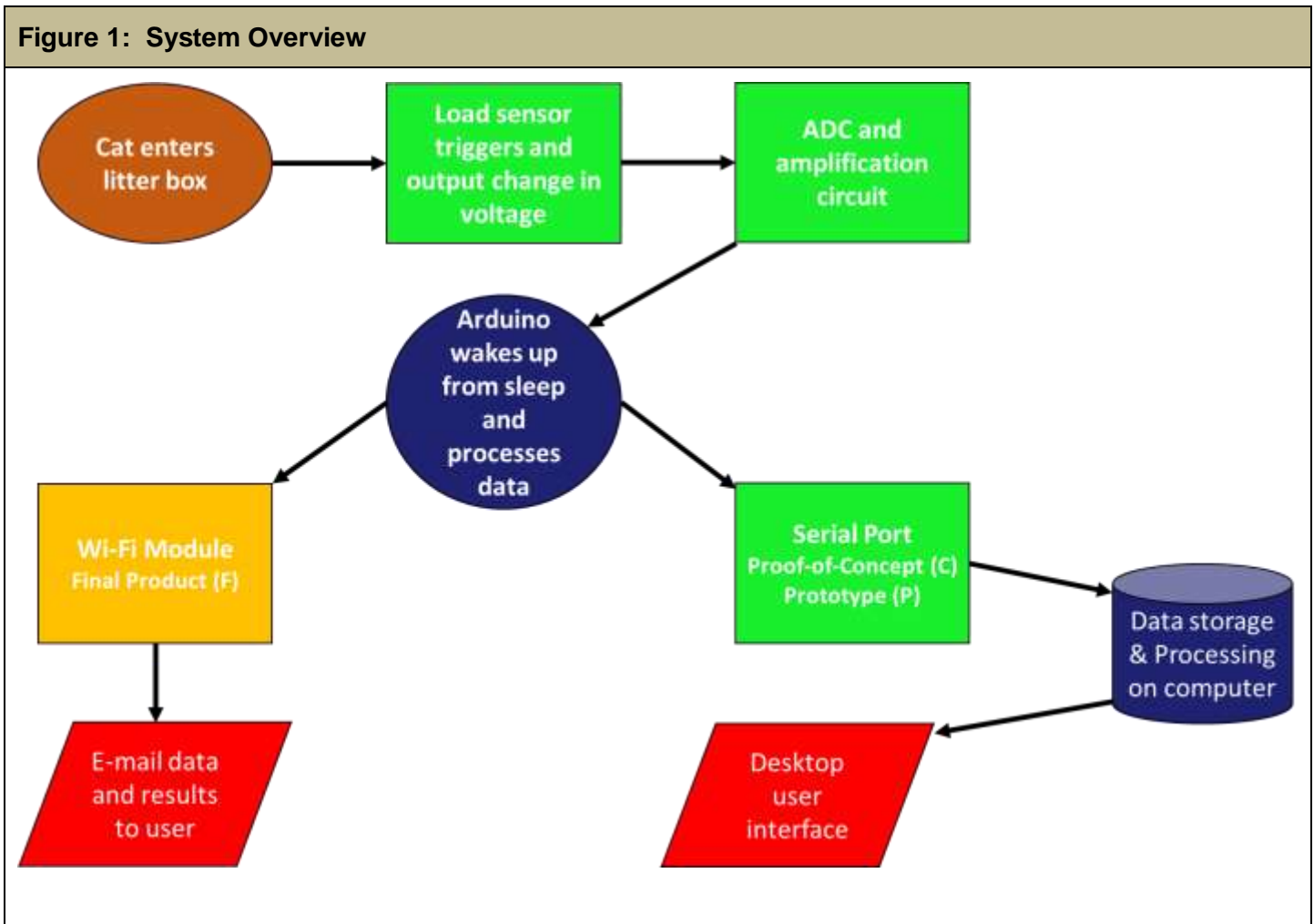




Our product will be convenient to use and operate due to the following features:

1. Surface that the litter box will be placed on top of (can work with existing litter boxes).
2. Battery operated, no need for nearby power outlet.
3. Long battery life, due to Arduino low power consumption.

Figure 1 below provides a high-level system overview of the Cat Health Monitor. When the cat enters the litter box, the load sensors are triggered, and the Arduino begins to collect data. The data will be sent to the computer through a serial port in the Proof of Concept (C) and Prototype (P) versions, but in the final product we will use a Wi-Fi module with the Arduino to send an email to the user(s).



High-level system overview of the Cat Health Monitor.



## 2.0 Benefits/Risks

### 2.1 Benefits

9 Lives' Cat Health Monitor provides many benefits for owners and their cats. These benefits will distinguish our cat health monitor from other similar products and put it competitively on the market. Just as pet owners take great responsibilities for their pets' health and longevity, 9 Lives places a great responsibility on itself in delivering a great product to all users.

#### 2.1.1 Early Detection of Illnesses and Diseases

Typical owners do not weigh their cats or visit a veterinarian regularly. Often, when they visit a vet because of a noticeable distress in their pet, the illness has already advanced to a worse stage. The cat health monitor's ability to calculate the weight of the cat and waste, measure the pH level of the urine, duration in the litterbox, and frequency of usages will detect early signs of many diseases and put the owners ahead. Diseases and illness that are detected include obesity, feline lower urinary tract disease, intestinal parasites, cancer, and many other diseases due to weight loss [4,5].

#### 2.1.2 Visualization and Analysis of Cat's Biometric Data

The cat health monitor collects data over time and visualize the data in tables, graphs and charts. The visualized data is then presented to a vet for quicker and more accurate diagnosis of diseases. The visualization is also used for better checkups and monitoring of pets. In addition, the cat health monitor alerts the owners of anomalies like increase or decrease in weight, abnormally long durations, and peculiar litterbox usage patterns.

#### 2.1.3 Modularity

The cat health monitor is installed and secured on an existing litterbox, so owners can set it up in their pets' current environment. There will not be any major change in their environment, which could induce stress and unwanted behaviors. The cat health monitor is also easily detachable for cleaning the litterbox and packed for travelling.

#### 2.1.4 Non-invasive and Inconspicuous

The curiosity of a cat may generate some unwanted attention to the cat health monitor like it's a new toy. Therefore, the cat health monitor is designed to be unnoticeable by the cat. Hiding under the litter, it does not need to come in to direct contact with the cat to measure the weights and duration. The concealment of the product will minimize the risk and chances the cat will misuse the product and hurt itself on it.

### 2.2 Risks

With any device that comes in close contact with a living thing, safety for the pets and users is 9 Lives' top priority. Potential risks are considered in all phases of development to ensure they are prevented, and the possibilities minimized.



### 2.2.1 Destabilization due to Excessive Force

Cats can have unpredictable movements and they can't read manuals or instructions to how to safely use a product. So, the cat health monitor needs to be designed to not shift or break under typical cat actions like jumping, pushing, hitting, etc.

### 2.2.2 Electrical Shortage

The cat health monitor contains many electrical components and live wires that will be near liquids. At 9 Lives, we take extra precautions to make sure the electronics are isolated from the cats with a waterproof casing. The casing also needs to be tough for reasons explained in the risk above, so the casing doesn't crack open and expose the electrical system to a curious cat.

### 2.2.3 Error in Data

One of the most important features of the cat health monitor is its ability to collect data about an owner's cat and produce useful visualizations. These are sensitive data that represents the well-being of an owner's cat and misinformation can cause a lot of problems. Environmental noise, user error in installation, and cat misuse can cause inaccurate weight measurements and false detection of cats and waste products. To prevent these errors, the weight sensing threshold of the cat health monitor will be carefully adjusted so that small noise objects like hair, dust and food crumbs will not be measured. There will also be error control in the microcontroller programming to catch error-like patterns and alert the users that there maybe some issue with the cat health monitor.

## 3.0 Market/Competition

### 3.1 Market

Currently, Cat Health monitor is targeting a Canadian market; as resources and funding grows, the goal is to expand to the North American market, and then internationally. Table 1 below shows the number of cat owners and veterinary clinics in our specified markets.

Table 1: Size of the Specified Residential and Clinical Markets

| Market          | Number of Residential Cats | Residential Market Size [12] | Residential Cat Litter Box Market       | Veterinary Clinics  |
|-----------------|----------------------------|------------------------------|---|---------------------|
| Canada          | 7.9 million [6]            | \$7.7 billion CAD            | N/A (Extrapolated to \$390 million CAD) | 3,224 [9]           |
| North America   | 82 million [7]             | \$80 billion USD             | \$3.9 billion USD [13]                  | 29,000 [10]         |
| Internationally | 600 million* [8]           | \$195 billion USD**          | N/A (Extrapolated to \$10 billion USD)  | 1.8 million*** [11] |

\* The number of cats internationally is a rough estimate and includes feral and stray cats, so this number is inflated.

\*\* Using a conservative estimate of 200 million residential cats

\*\*\* This is the number of veterinarians, not veterinary clinics, so this number is inflated.



The pet industry is growing as more people are getting pets as companions and millennials are willing to spend more on their pets. This industry in Canada alone is currently over \$ 7 billion on only upkeep alone. With cat owners visiting the vet more often than dogs (at a rate of 2.1 times a year) [9], our product has a large market for our clinical application. The US is the leading country in the number of households owning cats with 74 million household cats, so having the US as our secondary market after establishing a strong market in Canada is the direction of 9 lives. These merely provide a brief glance at the market and total spending on a cat to give a reference to how much the Cat Health Monitor is compared to yearly spending. Not many conclusions can be drawn, but that there is a market there. Although cat accessories and necessities are a red ocean, the smart health monitoring aspect of pet care is still a blue ocean, not yet saturated as it is a fairly new market.

The cat litter box market is expected to grow 7 to 9 % from 2018. With smart litter boxes and self-cleaning litter boxes, the market is becoming more autonomous and add-ons are becoming desirable. Although our litter box fundamentally is not a self-cleaning litter box but is instead a data collection method to provide vets with information for better diagnosis, our product has similarities to the following competitors.

### **3.2 Competition**

Many companies are currently developing smart AI powered cat monitor. The main advantage of the Cat Health Monitor is that it is small and an add-on to existing litter boxes. The device is also targeted towards the clinical market providing further urinalysis testing. Top competitors to 9 Lives in the global cat litter box market are Nature's Miracle, Petmake, Catit, Modkat, Purina Tidy Cats, IRIS, Little-Robot, Arm & Hammer. Among these big companies, there are also startups creating smart cat litter box systems. Many of these companies focus mainly on AI powered cleaning, and few boast of cat health tracking benefits.

On Kickstarter, a global crowdfunding platform, Footloose (see Figure 2 for more details): next generation automatic & health tracking cat potty, is the most funded pet product. Footloose is the Cat Health Monitor's main competitor with over \$1.3 million USD of funding backed by 3600 funders. It boasts of AI powered analysis along with their main focus of being self cleaning. Although the litter box is self cleaning, the box itself is large and requires a lot more space than cat owners' current litter boxes. Aside from the spatial costs, Footloose may self clean the litter, but the box itself will require cleaning as well which we expect to be a troublesome task with deep crevices. We are encouraged by the funding of Footloose, as it shows interest by cat owners for a smart product that assists in their cat's health and ease of cleaning.

**Figure 2: Footloose**



*Footloose: self-cleaning and health tracking competitor [14].*

Another major competitor is Litter Robot (see Figure 3 for more details). It boasts to be the highest rated, automatic, self cleaning litter box for cats. Similarly to Footloose, Litter Robot boasts of its self-cleaning aspect rather than the ability to monitor a cat's health. The latest (3rd generation) model sells for just under \$450 USD. The price, much like Footloose is high due to the self-cleaning aspect. Little Robot, much like Footloose, is a product aimed to benefit the user's experience through self cleaning, which is a different goal than the Cat Health Monitor at 9 Lives.

**Figure 3: Litter Robot**

*Litter Robot: self-cleaning litter box competitor [15].*

The Cat Health Monitor targets a clinical market, which cannot be reached by our competitors mentioned above due to the size of their product, along with a residential market. The product targets the health of a cat rather than the ease of the user, and because of that, 9 Lives is able to target a market different to larger competitors mentioned above.

## 4.0 Company Details

Founded in January 2019, 9 Lives aims to improve the lives of cat's and allow cat owners to know that their cat's digestive health is problem-free. The Cat Health Monitor will provide owners with a lot of peace of mind for a relatively low cost. Our company logo is shown in Figure 4. The company 9 Lives is composed of 6 team members:

- Gary is a 4<sup>th</sup> year Computer Engineering student with a first degree in Physics. He has completed a 16-month co-op at Ballard Power Systems and works there full-time as a Product Development Engineer helping to build an unit cell level fuel cell design tool that is fast and robust. He has experience in creating user-friendly interfaces, optimizing code, data analysis and good communication skills. He is interested in mathematics, physics, computing science and engineering and putting his skills to use to help humanity progress forward and work towards a sustainable future.
- Hakeem is a 4<sup>th</sup> year Systems Engineering student who is interested in Artificial Intelligence. He has completed an 8-month co-op at Sierra Wireless as a Software Test Engineer helping to design and build an automated test bench for their wireless embedded modules. Hakeem will apply his knowledge in sensors to ensure that the electrical side of the weight sensing system is precise and effective.



- Harinderpal is a 4<sup>th</sup> year Computer Engineering student with an interest in embedded systems. During his 8-month co-op term at Exegin Technologies as an Embedded Firmware Engineer, he worked on low-level software and a network topology viewing tool to help debug network issues. Harinderpal will be using his combined experience in hardware and software to work on getting the weight sensor output to the Arduino processor.
- Brandon is a 4<sup>th</sup> year Electronics Engineering student. His interests include electronic devices, embedded systems, and Android development. He has past experiences developing embedded systems in biomedical devices in Menrva Research Group at SFU and working as a student transit systems engineer at TransLink. Brandon's hardware and embedded systems experience will be useful in developing and verifying the sensor circuit and its integration with the Arduino microcontroller.
- Timothy is a 4<sup>th</sup> year Biomedical Engineering student with an interest in data analysis and big data. During his 8-month co-op term at Cooledge lighting as a Characterization Engineer, followed by his 4-month co-op term as a Quality and Reliability engineer, he collected and analyzed data to test the reliability and performance of optical products. His interest in big data was developed during his 8-month co-op term in SFU's Biomedical Optics Research Group utilizing machine learning to analyze data. Timothy will be using his experience with data to work on programming conditional algorithms along with potential AI driven analysis.
- Gabe is a 4th year Computer Engineering student. He is originally from Toronto, Ontario, and he obtained a Bachelor of Arts from the University of Guelph in 2013. Gabe recently completed an 8-month coop term where he was responsible for writing Linux-based device drivers. His first coop position was largely hardware based and involved designing and debugging PCBs. Gabe has spent most of his life living with animals. His father is a Veterinarian who owned a clinic in Toronto for over 20 years and his sister is currently in her 3rd year of vet school

**Figure 4: Company Logo**



*9 Lives company logo.*

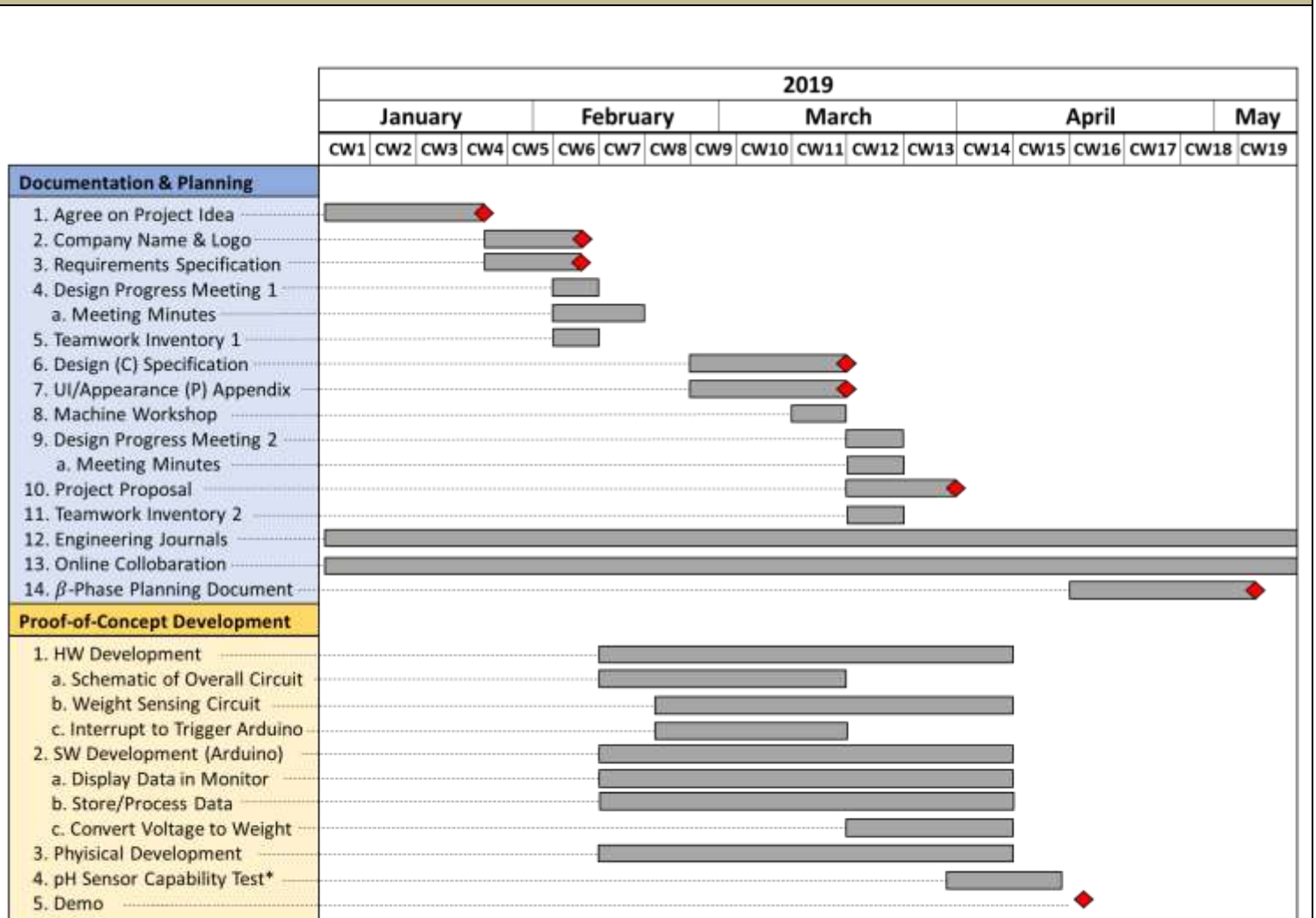




## 5.0 Project Planning

Figure 5 shows the Gantt chart outline the team’s scheduling to meet all the milestones required for ENSC 405W. The milestones shown in the chart correspond to the milestones defined in our GitLab online environment.

**Figure 5: Gantt Chart for Proof-of-Concept Development of the Cat Health Monitor**



CW – Calendar Week  
 HW – Hardware  
 SW – Software  
 ◆ – Milestone (corresponding to milestones in GitLab)  
 \* Optional





## 6.0 Cost Considerations

Table 2 shows the cost of the main components in the proof-of-concept version of the Cat Health Monitor.

Table 2: Size of the Specified Residential and Clinical Markets

| Item                              | Quantity | Price Per Unit             | Source    |
|-----------------------------------|----------|----------------------------|-----------|
| HX711 Opamp/ADC                   | 1        | \$12.00 CAD                | Amazon    |
| 2x 50kg Half-Bridge Weight Sensor | 2        | \$8.86 CAD                 | Amazon    |
| 3x Arduino Nano V3                | 1        | \$18.65 CAD                | Amazon    |
| Cat Litter Box                    | 1        | ~\$9.00 CAD                | Pet Store |
|                                   |          | <b>Total = \$48.51 CAD</b> |           |

### 6.1 Funding

The total cost of material and components is low enough that the 9 Lives team can fund itself to build the proof of concept and engineering prototype. Each member has agreed to equally contribute to the cost of building the multiple stages of the product. For the final product, 9 Lives and its health monitor will need to attract investors to manufacture the products. But before the final product, if the team is not able to gather enough fund to build the prototypes, there are few available options:

1. The Engineering Science Student Endowment Fund, ESSEF at SFU was created for the purpose to fund SFU engineering students' projects.
2. Wighton Engineering Development Fund is also a good option. Although, preferences are given to projects benefiting society, 9 Lives' cat health monitor do benefit a small part of society, the community of owners and pets.
3. \$50 parts budge from SFU Engineering Science can come in handy when there is just a little shortage on funding for some components.

## 7.0 Conclusion

The quiet nature of cats is what draws many to having them as pets. However, the same trait can cause health issues to go unnoticed until serious complications arise. The team at 9 Lives aims to alleviate this uncertainty with the Cat Health Monitor by providing cat owners frequent updates on their cat's health indicators and sharing early signs of potential health issues.

The Cat Health Monitor will use weight sensors and a pH sensor to collect pertinent data and perform analysis on it to chart trends and find irregularities. This analysis will be based on veterinary feedback on the key symptoms to look for when tracking a cat's health such as rapid weight loss, infrequent visits to the litter box, high pH in urine, among others.



Our company's focus on affordability and simplicity drove us to make the Cat Health Monitor a base for an existing litter box to go on top of instead of a completely new integrated litter box. This sets our product apart from the competition and accommodates a customer and their cat's existing habits with a minimal learning curve and a reasonable price.

We would like to thank Dr. Craig Scratchley, Dr. Andrew Rawicz and the Teaching Assistants for helping us both with an overall guidance and specific feedback and suggestions on improving our product and fleshing out important details. Our experience in ENSC 405W has been very insightful and we look forward to our time in ENSC 440.

## 8.0 References

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