March 28, 2018

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

Re: ENSC 405 Requirements Specification for *DeepBreath*

Dear Dr. Scratchley,

This document contains a project proposal for *DeepBreath*, a smart training mask that measures metrics about a user's fitness, and presents them meaningfully on their devices. Our chief concern in this project is to produce an affordable device that is accessible to a wider range of people than what is already on the market. We will also strive to maintain a simple and elegant user interface, and rugged design to provide a high level consumer experience.

This document intends to introduce the scope and overview of our proposed product. More specifically it will discuss the prototype design, anticipated risks and benefits, market analysis and competition, cost of materials, and a schedule for goals and milestones in the current and next semester. A detailed overview of the Exotic company and its members will be provided as well.

Our diligent team consists of 4 senior engineering students in the SFU program - Alex Boswell, Austin Phillips, Jim Park, and Sulaiman Omar Marouf. We plan to meet consistently and hold each other accountable for this project, and are confident we will produce a successful product.

Thank you for reviewing this proposal document. If you have any questions or concerns, please contact us through GitLab or contact Jim Park, our Chief Communications Officer, at jim_park@sfu.ca.

Sincerely,
Austin Phillips
Chief Executive Officer
Exotic

PROJECT PROPOSAL

For

DeepBreath

Get more out of every breath

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Executive Summary

The fitness industry is a booming global market. Athletes and fitness enthusiasts around the world are getting faster, stronger, and more interested in the idea of being able to take their fitness journey to the next level. However, the technology for tracking a person's fitness progress at an advanced level is not yet available for the average consumer—at least not at an affordable price. Currently, only the well-funded, elite athletes have access to such tools.

Exotic aims to provide a solution to this problem by creating *DeepBreath*. *DeepBreath* is a device that is able to offer advanced analysis and tracking of specialized fitness metrics for anybody, from your average Joe to serious athletes. It is a training mask that analyzes the gas levels of the user's breath, and processes them into significant measures of their fitness. This provides a portable and convenient way for keeping track of the user's progress.

Although few in number, there are products that exist on the market that are able to assess fitness metrics from breath analysis, and are aimed for commercial use. However, these products are still highly expensive, and are not realistically affordable options for your everyday fitness enthusiast. *DeepBreath* will be able to offer an alternative product for consumers who are still interested in specialized fitness analysis, but are seeking a cost-effective solution with less focus on overly precise measurements.

Exotic is comprised of four highly experienced and skilled engineering students with diverse backgrounds in technical development. Each individual has significant and professional experience in the engineering industry, and the team is certain of its ability to deliver a quality product for *DeepBreath*. Furthermore, careful considerations have been made in the planning of the project development to ensure that every expected feature and deliverable can be completed at a reasonable time frame.

The remainder of the proposal document will provide a more detailed insight into the work our company has done so far, and forecast the next steps in the development of our prototype. Furthermore, each section of the proposal will examine the viability of *DeepBreath* from a different point of view. Sections such as Market and Cost Analysis will explicitly discuss the profitability, while the Risks, Benefits, and Project Planning sections will examine the project from a higher level, and show that Exotic has been circumspect in our predictions about DeepBreath.

"Get more out of every breath."

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Glossary

BLE Bluetooth Low Energy is a wireless communication standard that has lower power consumption compared to its regular Bluetooth counterpart.

MSRP Manufacturer Suggested Retail Price. Used to define how much a product should be sold for at retail.

Respiratory Exchange Ratio (RER) The ratio of oxygen to carbon dioxide in a person's exhale breath, which is used to determine information about the body's internal processes.

VO_2 max Commonly known as the maximum oxygen consumption, which measure the amount maximum amount of oxygen a person may use during a defined period of physical activity.

1 Introduction

The biggest advantage professional athletes have in fitness improvement is their usage of specialized resources and technology. They have trainers, diets, physical therapy, and a wide range of equipment designed to provide metrics about their fitness levels and progress. Average people, or even lower-level dedicated athletes, don't have the time, money, or opportunity to use any of these services.

Exotic recognizes this problem, and wants to solve it. To accomplish this, we decided to create *DeepBreath*, a device that will provide affordable access to some of the progress tracking and real-time metrics commonly tested in elite athletes. One of the most common of these metrics is a **VO_2 max** max test that measures the amount of oxygen that a human can use in a certain period of time. Usually, these tests are done in a lab with bulky, immobile equipment. The system captures the gasses that the athlete exhales throughout their period of exertion, and provides feedback about their fitness levels. Many other metrics, such as the **Respiratory Exchange Ratio (RER)**, are determined in a similar fashion. *DeepBreath* condenses and rearranges the in-lab system into a wearable, portable mask. Small electronic sensors are used to measure the breaths of the athlete, and the results are provided over a smartphone application.

There are devices that have achieved portable breath measurement of this kind, but they are prohibitively expensive. The goal of *DeepBreath* is to create a product in a cost-efficient manner so that it can be profitably sold at a price affordable to average consumers. We hope that in doing so, we might allow people to work on their fitness as professional athletes do, and promote a healthy lifestyle in the process. Exotic is very excited about *DeepBreath*, and we are certain that its users will be too.

2 Project Overview

2.1 Background

The *DeepBreath* system will provide analysis of the gasses in it's user's breath, and report meaningful fitness metrics. Two of the metrics that team has focused on are VO_2 max and RER. VO_2 max is a measure of the amount of oxygen the body can process over a defined period of intense exercise. If one has a high VO_2 max, it is a strong indication that they have high cardiorespiratory fitness. The RER discerns whether the body is burning carbohydrates or fat for energy. This is very useful information for people to determine the success of using specific diets or workouts that target fat burn. We hope to include many more metrics as the project develops, but these two will be a strong start. The calculations for these metrics are defined below.

The VO_2 max is calculated using summation of breaths over period of time: [1]

$$V_{O_2}\ Max = \frac{Total\ Volume \cdot (V_{O_2\_in} - V_{O_2\_out})}{Weight} \tag{2.1}$$

Where:

Total Volume is the sum of the volumes of every inhalation in the time interval;
VO_2_in is the average percentage of oxygen in all inhalations in the interval;
VO_2_out is the average percentage of oxygen exhaled;
$Total\ Volume \cdot (VO_2\_in - VO_2\_out)$ is the average percentage of oxygen in all inhalations in the interval;
Weight is simply the weight of the user in kilograms.

The RER can also be calculated using summation of breaths over period of time: [2]

$$RER = \frac{V_{CO_2}}{V_{O_2}} \tag{2.2}$$

Where:

$$V_{CO_2} = \frac{Total\ volume\ of\ air\ exhaled}{\%CO_2\ in\ exhale\ breath} \tag{2.3}$$

$$V_{O_2} = \frac{Total\ volume\ of\ air\ inhaled}{\%O_2\ in\ inhale\ breath - \%O_2\ in\ exhale\ breath} \tag{2.4}$$

Both values are calculated in a short time interval (approximately 10 seconds).

2.2 Scope

The main scope for the project is to construct and deliver a working prototype for the *DeepBreath* product. Our goal for this device is to create an affordable and convenient way for consumers to be able to keep track of their fitness progress.

The device must be able to measure meaningful types of fitness metrics of a given user using their breath. In the scope of this project, the ability to calculate and analyze the user's VO_2 max and respiratory exchange ratio will be the main design focus. *DeepBreath* will also provide a lightweight companion application for the users' mobile devices. The app will be responsible for the analysis and display of the fitness metrics in an intuitive and user-friendly way.

The figure below describes the high-level architecture of DeepBreath.

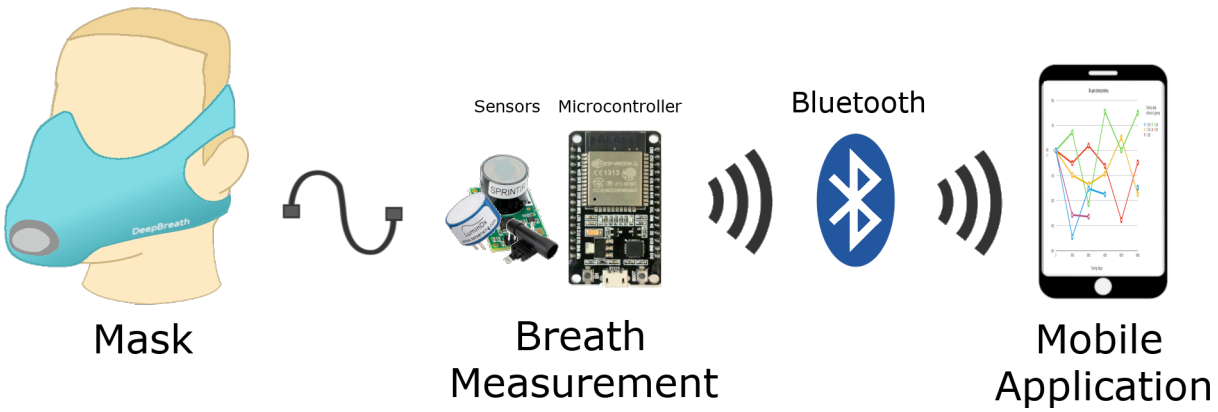

Figure 1: Overview of *DeepBreath*'s Components

The three main components that *DeepBreath*'s system is comprised of are:

1. **Fitness Mask**
   The physical, wearable mask in which the measurement circuitry are housed.

2. **Breath Measurement System**
   The sensors and microcontroller that make up the circuitry responsible for measuring and analyzing the properties of the user's breath.

3. **Companion Mobile Application**
   The phone app is paired via **BLE** to the microcontroller. The app is responsible for receiving the transmitted measurement data from the mask and performing calculations to transform them into meaningful fitness metrics. The app will also be responsible for displaying and storing the user's fitness progress.

There are several important design objectives that *DeepBreath* must fulfill in order to meet this vision:

1. Be able to measure with relative accuracy the chemical contents and flow rate of the user's breath during exercise.
2. Provide a comfortable and adjustable mask that does not interfere during physical activity.
3. Be able to transmit sensor readings in real-time via BLE with no errors.
4. Provide a mobile application that pairs with the mask via BLE, that can receive the data readings in real-time.
5. Be able to calculate meaningful fitness metrics from the raw data within the phone application.
6. Keep track of the user's fitness progress over time, and display in graphical formats.

At the end of the first 4 month period in the development phase of *DeepBreath*, a proof-of-concept prototype will be delivered. The main focus for this deliverable is to implement the breath measurement system; the functionality for collecting data from the user's breath with sensors will be complete, as well as being able to transmit this data to the mobile application through BLE. The app will be fairly basic, as the focus at this stage is on demonstrating the capability of accurately measuring the contents of the user's breath.

In the following 4 months after the proof-of-concept prototype is delivered, development for the engineering prototype of *DeepBreath* will begin. At the end of this period, the rest of the planned features will be implemented especially concerning the mobile application, including the ability to calculate fitness metrics, store data over time, and displaying in graphical formats. Further polishing and optimization will occur regarding the circuitry and how it is housed within the mask.

2.3 Benefits

Health and Safety

Exotic takes the health and safety of our users very seriously, and the design of *DeepBreath* confirms this. Air freely flows in and out of the mask, so users won't have any difficulty breathing. The chosen sensors are entirely self contained and do not affect the quality of the air entering the users lungs. Furthermore, the power dissipation of the system is so low that there will be an exremely low risk of high temperatures in the electronics of *DeepBreath*.

Affordability

Affordability has been paramount in the design of *DeepBreath*. We hope to be able to offer it an order of magnitude cheaper than similar products on the market. We are confident that this will be the primary edge *DeepBreath* has over our competitors.

Intuitive Design

Similar to other Bluetooth products, the user will have to pair their mobile phone to the *DeepBreath* mask. Our product is designed in such a way that the setting up the mask and beginning a training session will be quick and easy. Careful consideration has been put into the user interface design of the mobile application, especially in regard to the pairing and session starting operations. For specific details regarding our approach in interface design, please refer to the User Interface and Appearance Design Appendix in the Design Specifications document. [3]

Portability

The *DeepBreath* mask is lightweight and and comfortable to wear, and its electronics are simple and rugged. So, the system will effectively replicate lab-based breath testing results, but also be completely portable.

2.4 Risks

Reliability

In the design of *DeepBreath*, we opted for cost-effective components to create an affordable solution. Therefore, some of the measurements or metrics we provide may lack slightly in precision or accuracy compared to the high-cost alternatives on the market. Though, given the nature of the metrics we plan to track the accuracy and precision is less of a problem than on might expect. As the intention is for the user to track their results over time, the trend is what is primarily important, not the exact measurement. In any case, we believe this was a sacrifice worth making in the spirit of the project.

Market Competition/Acceptance

Though the wearable fitness device market is large and has room for new products, it will still be difficult to get a foothold. It is currently dominated by very large companies like FitBit and Garmin that boast huge customer bases. However, we intend to market *DeepBreath* in a manner that will avoid direct competition with these firms. Given their size, they often sponsor huge sporting events or teams for publicity, and sell their products in large chain stores like Sportchek. We hope to market *DeepBreath* through fitness influencers on Instagram, YouTube and other social media outlets to drive consumers to an online store where they can buy from us directly. In this way, we could generate awareness of our product, and move into more close competiton with large companies later.

Wear Over Time

As *DeepBreath* is still in early phases of design, we haven't yet been able to test how it will hold up to extended wear and tear. There are not glaring reasons to suggest it would perform poorly in this manner, but if problems arise we may need to issue a redesign that allows for replaceable parts, or offer tune-ups.

3 Market and Competition

DeepBreath aims to be a cost effective solution for the average athlete and fitness enthusiast who wishes to see their fitness metrics without having to spend large amounts of money. To identify our target consumers, we first considered base income levels and spending habits. With our rough cost estimates, *DeepBreath* hopes to sell to those who lie in the middle to upper class income bracket and live in places that have a high household spending, which refers to the total amount of money spent by resident households on items such as clothing, food, leisure and miscellaneous services [4]. We also looked at household disposable income, which is defined as the "sum of household final consumption expenditure and savings, minus the change in net equity of households in pension funds" [5]

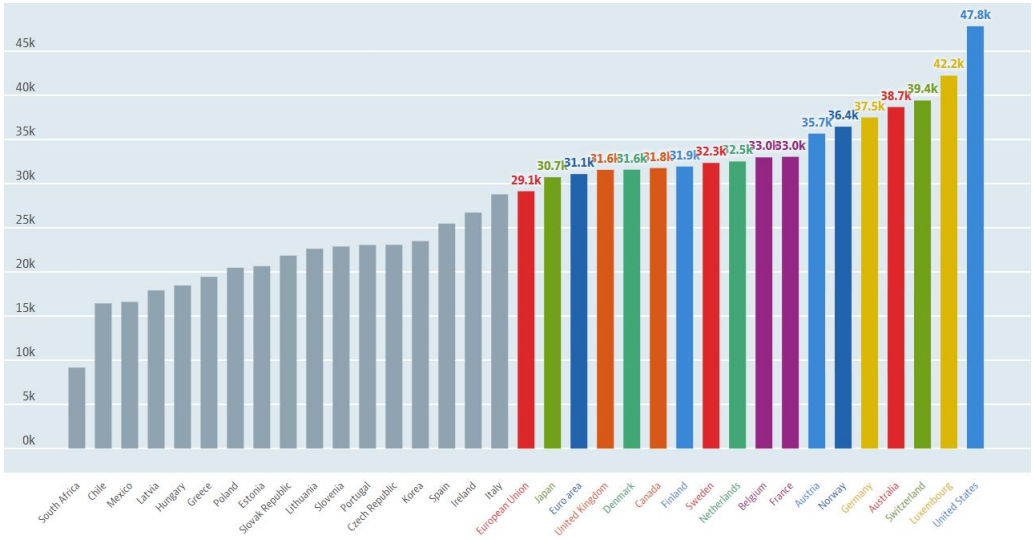

Figure 2: Household disposable income, Gross adjusted, US Dollar/Capita, 2016

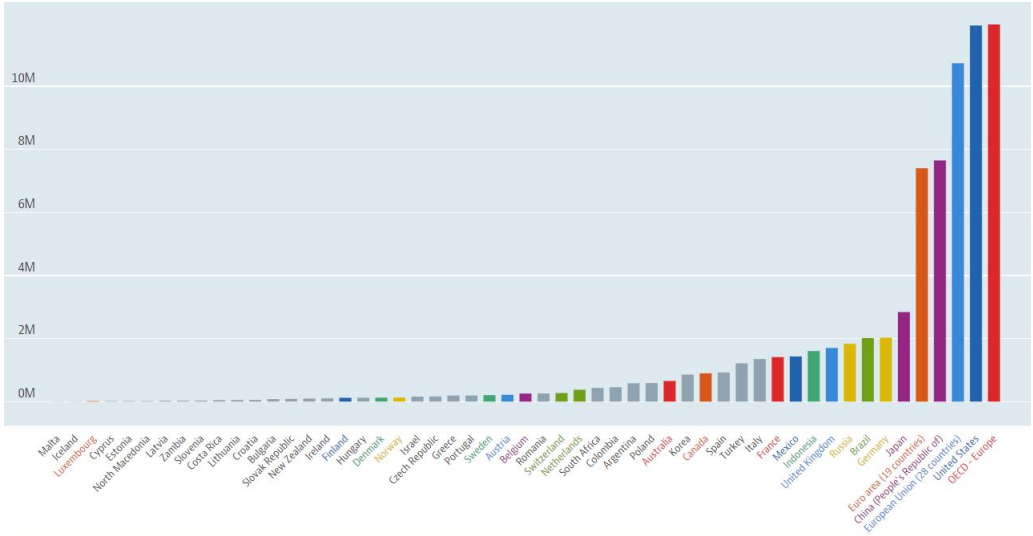

Figure 3: Household spending, Total in Million US dollars, 2015

Looking at the figures above we see that our the majority of our consumers will lie within countries such as Canada, United States, China, United Kingdom, and the European Union. From here, we can narrow our target consumer again by splitting our product into two markets where we believe it will succeed in.

3.1 Main Target Demographic

The first and main target demographic is the every-day fitness enthusiast. This consumer range refers to hobbyists who partake in any sort of physical activity. A survey done in 2018 suggested that on average, US adults spend $2000 a year on health and fitness related activities. Nearly 87% of Americans believe that fitness classes are extremely important, with some spending much more than the yearly average. [6] Another study by the Global Wellness Institute stated that with a market share of $3.4 trillion, the global wellness market is nearly three times larger than the worldwide pharmaceutical industry. These surveys and studies clearly show that there is a demand within the market for a device such as *DeepBreath*.

3.2 Wearable Fitness Devices

The wearable fitness device market has seen an extremely large upward trend in the last few years. An extremely well known device for the wearable health and fitness industry is the Fitbit. In 2016 over 55.2 million fitness trackers were sold. By 2022 this number is estimated almost double at nearly 105 million devices sold [7]. With various products ranging from 59.95 USD to 299.95 USD, it's evident that people are willing to pay for fitness devices in the range we hope to sell *DeepBreath*.

3.3 Secondary Target Demographic

The second market *DeepBreath* aims to succeed in is with amateur athletes. We define amateur athletes as those who wish to elevate their level within a sport but lack the resources that a professional league or team can provide, and thus are rely on personal funds. These athletes are commonly not in a position to afford extremely expensive equipment.

3.4 Competition

The competitors within the wearable facemask fitness device market is extremely limited. The only product that is currently available on the market for personal use is VO2 Master. In terms of pure functionality, both VO2 Master and *DeepBreath* have very similar features. However, one of the largest drawbacks of VO2 Master is its price. With an **MSRP** of $4,999 and a yearly 'service' fee of $499 [8] the product is extremely expensive. Due this reason alone, we firmly believe consumers will opt to purchase *DeepBreath*.

4 Cost Analysis

4.1 Budget and Detailed Costs

The price breakdown of each component as required in the design of the *DeepBreath* prototype is listed below.

Table 4.1: Price Breakdown of Prototype Components

Type	Part Number	Quantity	Unit Price	Total Price
Sensor	LOX-02	1	$90	$90
Sensor	SprintIR-WF-100	1	$115	$115
Sensor	AWM730B5	1	$250	$250
MicroController	ESP-32	1	$25	$25
Power Supply	Anker Astro E1	1	$22	$22
Mask Material	Training Mask	1	$20	$20
			TOTAL	**$522 CAD**

Some additional parts were bought to act as spares. The prices for these contingency components are totalled in the table below.

Table 4.2: Price Breakdown of Contingency Components

Type	Part Number	Quantity	Unit Price	Total Price
Sensor	LOX-02	2	$90	$180
Sensor	SprintIR-WF-100	2	$115	$230
			TOTAL	**$410 CAD**

Currently, our production costs are significantly higher than we had hoped, and will need to be improved once we move out of the prototyping phase. The unit price of all parts will decrease at scale, but we will still need to search for different options. We are confident that we will be able to find better solutions in the later stages of our project.

4.2 Funding

There are a couple of potential sources of funding that Exotic could secure for the prototype development of *DeepBreath*.

The Engineering Science Student Endowment Fund (ESSEF) has been a longtime sponsor of student-led entrepreneurial projects at Simon Fraser University. The *DeepBreath* project falls under Category B in their Rating Criteria, "for projects that expect to produce a workable prototype". [9] We will be able to submit an application earlier on in Summer 2019 to obtain funding for our project costs.

Another potential source of funding is the Wighton Engineering Development Fund [10], also a program at SFU that intends to support student-led engineering projects.

We are confident that we will be able to prepare a detailed and persuasive presentation for the funding decision committee, and describe the potential we see in our product.

If for any reason we are not able to secure funding from these sources, each member of Exotic is committed to provide personal monetary contributions to cover the costs incurred during the development of the prototype. Any outstanding expenses that are not covered by investor funding will also be evenly distributed among the team members.

5 Project Timeline

5.1 ENSC405 Development Schedule

The figure below shows the Gantt chart outlining the major tasks and milestones to be accomplished through out the duration of ENSC405, mainly in developing the proof-of-concept prototype.

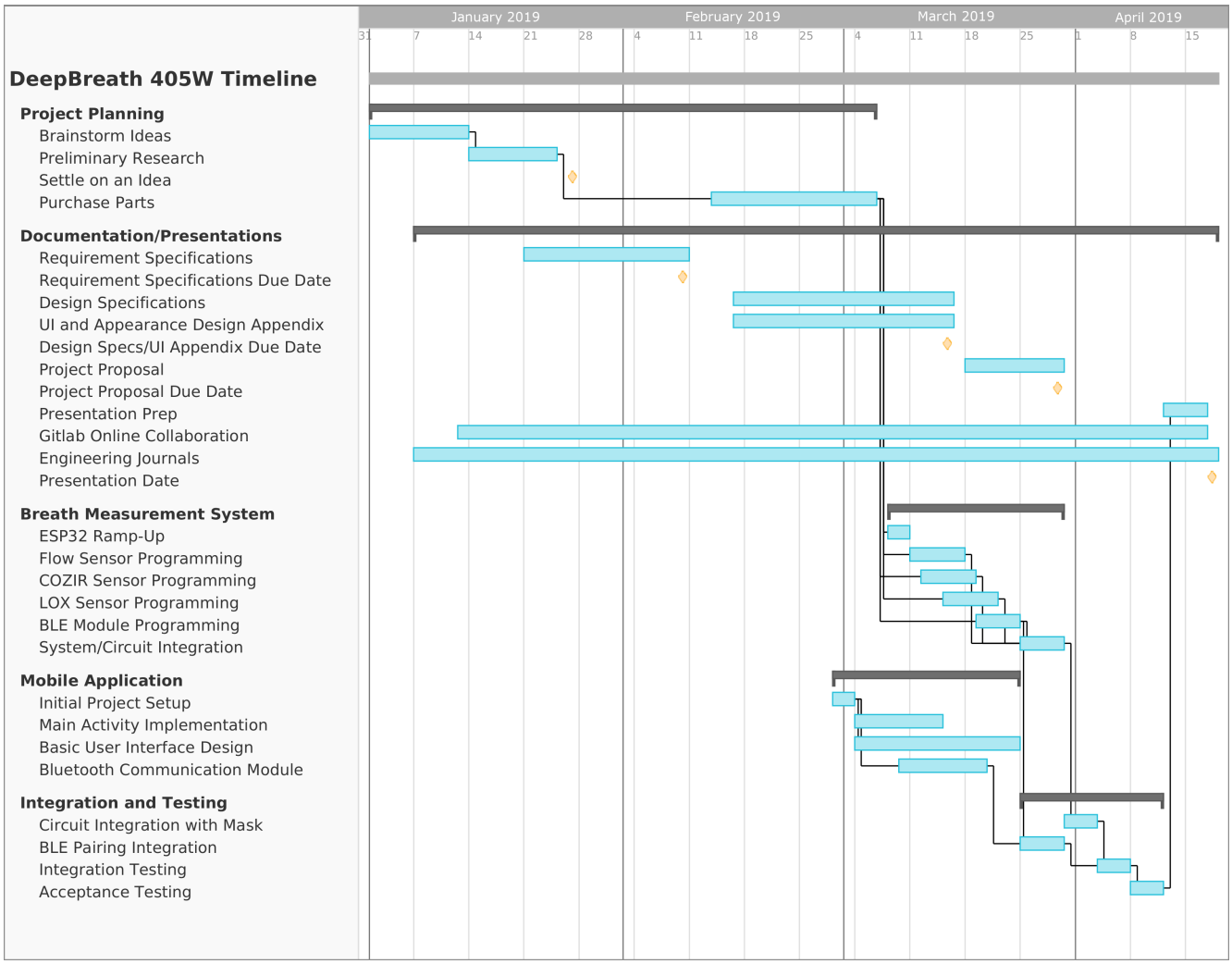

Figure 4: Gantt Chart for ENSC405

The specific dates for key milestones are shown in the milestone chart below.

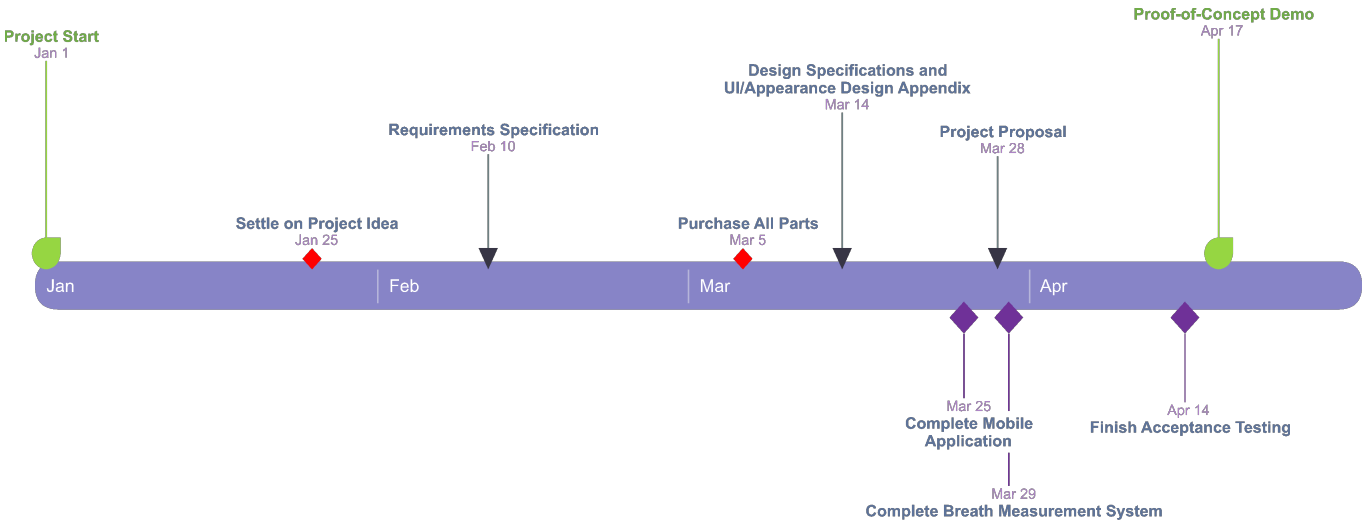

Figure 5: Milestone Chart for ENSC405

5.2 ENSC440 Development Schedule

At the time of this writing, specific dates for required submissions in the ENSC440 Capstone course are not available. However, the Gantt chart below outlines the general design deadlines for the engineering prototype development of *DeepBreath*.

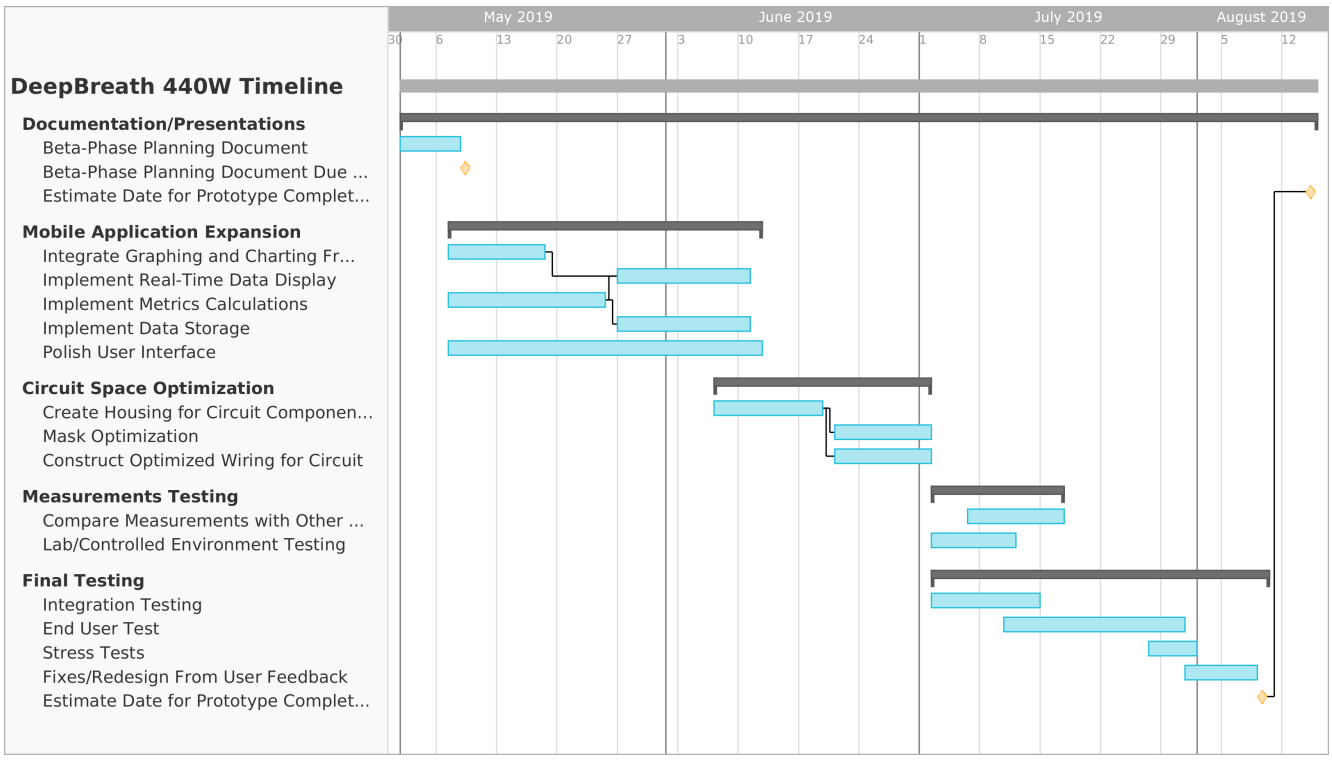

Figure 6: Gantt Chart for ENSC440

6 Company Details

Formed in January 2019, Exotic is a group of 4 senior students in the engineering program at SFU. Our objective is to produce cost-effective and meaningful tech solutions to empower our users. Our first product, *DeepBreath*, aims to break the cost barrier for visualizing advanced fitness metrics with fitness technology.

Austin Phillips | Chief Executive Officer

Austin's background is primarily in software engineering, with experience in quantum computing during his time spent at the Vancouver start-up, 1QBit. His primary programming skills are centered in C++,but he has worked with Ruby for web development, and app design in swift for iOS. Over Austin's co-ops he found an appreciation for UNIX based systems and classical IDE-less workflow.

Sulaiman Omar Marouf | Chief Information Officer

Sulaiman Omar Marouf is a systems engineering student with expertise in software development, microcontroller programming, and sensor interfacing. Currently, he is employed by Elastipath as a DevOps engineer where he handles product releases and cloud infrastructure.

Alex Boswell | Chief Technology Officer

Alex Boswell is a senior computer engineering student with co-op experience in enterprise level software development and automation development. Alex just returned from an internship at McKesson Corporation where he worked in an agile development team.

Jim Park | Chief Communication Officer

Jim is a senior computer engineering student with a background in software systems development. His previous co-op experience at FPInnovations and MDA Ltd. has given him extensive expertise in professional software design and development. He is currently part of a work-study program as a research assistant working with real-time computer vision and pointcloud technology.

7 Conclusion

DeepBreath will give users access to a professional training experience. It will motivate healthy living by allowing users to track their progress with quantifiable data. It will differentiate itself from other wearable fitness devices by taking this data directly from the users' breath. And, it will improve upon the competition by being available at a significantly lower cost. For all these reasons, *DeepBreath* is an amazing product, but Exotic will be focusing primarily on the last.

We want to bring this technology to average fitness enthusiasts, lower-level athletes, and anyone else without the ability to spend thousands of dollars on workout equipment. Given the success of companies such as FitBit and Garmin, and the facts presented in our market analysis, it is clear that this market is exploding. *DeepBreath* could be the first of its kind to reach consumers, and stake out a name comparable to those fitness technology giants.

Exotic hopes that it is clear how exciting of a product *DeepBreath* is, and how much potential it has for high performance on the fitness market. Each individual member on the team is motivated to deliver a quality product that will live up to our standards. With the right investors we could realize this vision.

8 References

[1] "VO2 max", En.wikipedia.org, 2019. [Online]. Available: https://en.wikipedia.org/wiki/VO2_max. [Accessed: 09- Mar- 2019].

[2] "Respiratory exchange ratio", En.wikipedia.org, 2019. [Online]. Available: https://en.wikipedia.org/wiki/Respiratory_exchange_ratio. [Accessed: 09- Mar- 2019].

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