February 7, 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 intends to highlight and propose high level requirements for *DeepBreath*, a smart training mask. *DeepBreath* will measure fitness metrics through a user's breath, and present them in a meaningful way on their devices. We are striving to create this product with low costs to significantly improve the accessibility of this type of information to regular consumers.

This requirements specification document first outlines the scope and intended audience of our product, and then describes the requirements related to the software, hardware, electrical components, and user interfaces for *DeepBreath*. Lastly, we will list the Engineering Standards that we will comply with as well as our plan to meet safety and sustainability requirements.

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 an impressive product.

Thank you for reviewing this requirements document and future documents. 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

REQUIREMENTS SPECIFICATION

For

DeepBreath

Get more out of each breath

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Abstract

This document specifies the functional requirements of Exotic's smart mask project *DeepBreath*. As the project is still in early design phases, the requirements described here will be generally high-level and could be subject to change as the project matures. However, it is clear that *DeepBreath* will be made up of 2 distinct parts.

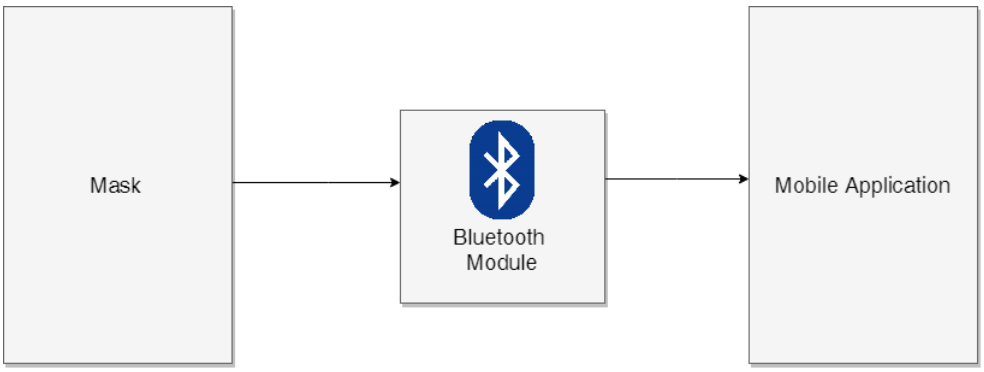

Figure 1: System Overview

1. The physical, wearable mask that contacts the user's face, and the electronics within it. The requirements for this component are mainly contained within the Mechanical, Safety, Hardware/Electronics, Sustainability, and Engineering Standards Requirements sections of this document.

2. The companion app that provides analytics and data display for the mask. The Software and Engineering Standards Requirements contain information on this component.

The intention of the *DeepBreath* project is to create a portable technology capable of providing test results similar to bulky lab equipment that determine fitness metrics through information in athletes' breath. A popular one of these metrics, and a main function of *DeepBreath*, is a VO_2 max calculation. To achieve this measurement in a portable device, Exotic plans to utilize optical O_2 and flow sensors to gather data, rather than rely on large closed systems found in labs [1]. Although there is a portable device that already exists on the market with these capabilities, it is exceedingly expensive [2]. Therefore, *DeepBreath* will attempt to reduce the cost significantly by sacrificing some accuracy of measurement, with the goal of the final product being a moderately priced option for consumers who want to get more out of each breath.

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Glossary

API An application programming interface is a subset of rules that software and applications follow in order to communicate with each other.

combine A sports combine is a combination of various sport specific activities to determine the strength, speed, endurance, skill of an athlete. It is usually done in front of coaches who wish to evaluate athletes.

CPU Central processing unit is a electrical component that deals with computation, log and other basic operations.

memory leak Failure to properly manage memory in such a way that memory which is unneeded is accidentally released.

QA Quality Assurance refers to the process of testing, debugging and assuring that the software/product works as intended.

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

1.1 Scope

This document intends to specify the functional design requirements and specifications for the *DeepBreath* training mask. The software, hardware, and mechanical requirements serve as an overview of the system functionalities to be delivered by the product. The document also outlines the product's compliance of various engineering standards, as well as the team's consideration for safety and sustainability.

In the appendix, the document includes a complete Acceptance Test Procedure for verifying that the requirements listed here are fully met. Also included in the appendix is the list of specific requirements to be delivered by the design team for the proof-of-concept prototype.

1.2 Intended Audience

The intended audience of this document is for all developers responsible for implementation and design of the *DeepBreath* product. The functional requirements and QA specifications outlined here will serve as a guideline during both the development and testing phases of the project, to be referenced consistently by Exotic's engineers. This process shall ensure the correctness and quality of the final product.

1.3 Requirements Classification

For the purposes of clarification and prioritization, the following convention will be used to label the functional requirements throughout this document:

Req [Section].[Subsection].[Requirement Number]-[Design Stage]

For the sake of clarity and readability, the different design stages will be abbreviated as follows:

PC - Proof-of-concept Prototype
EP - Engineering Prototype
PV - Production Version

As an example, the third functional requirement in the Software Requirements pertaining to the phone application back-end subsection, scheduled for the engineering prototype phase will be denoted as:

Req 3.1.3-EP

2 High Level Requirements

The High Level Requirements section defines the most general requirements of the overall system. It assumes that other, more specific requirements are met, and declares functional goals for a working prototype.

2.1 Operational Requirements

Table 2.1: High-Level Operational Requirements

[Req 2.1.1-PC]	*DeepBreath* shall be able to calculate and measure the user's **VO_2 max**.
[Req 2.1.2-EP]	*DeepBreath* shall be able to calculate and measure the user's **respiratory exchange ratio (RER)**.
[Req 2.1.3-EP]	The device shall be easy to assemble and disassemble.

2.2 Other Requirements

Table 2.2: Other General Requirements

[Req 2.2.1-PV]	*DeepBreath* shall be reasonably affordable compared to similar products in the market.
[Req 2.2.2-EP]	All systems shall be thoroughly and consistently tested according to the established Acceptance Test Procedure outlined in the Appendix section of the document prior to being commercially shipped.

3 Software Requirements

The mobile application for *DeepBreath* is the main software component for our system. As most of our team's expertise is in software, we will strive to make the application software contain solid code that is efficient, robust, clean, and secure.

3.1 Phone Application Back-End

The analysis and processing of measurements obtained from the sensors will occur in the application software. Once the readings are transmitted over, calculations can be performed on the data to evaluate fitness metrics for the user, such as VO_2 max. In addition, the application will allow saving of the analyzed data into the mobile device's storage for viewing at the user's convenience.

Table 3.1: Phone App Back-End Requirements

[Req 3.1.1-PC]	The app shall be able to handle incoming data being received from the mask.
[Req 3.1.2-EP]	The app shall be able to process data readings received from the controller and calculate meaningful information (e.g. VO_2 max) from them.
[Req 3.1.3-PC]	The app shall use the Bluetooth capabilities within the phone to pair with the mask.
[Req 3.1.4-EP]	The portions of the app that are multi-threaded shall be thread safe.
[Req 3.1.5-EP]	The app shall allow the saving of analyzed data tn the user's mobile device that can be opened and displayed at a later date.
[Req 3.1.6-PC]	The app shall be compatible with Android devices.
[Req 3.1.7-PC]	The app shall at minimum target and be compatible with devices that are of version number Android 8.0 (**API** level 26).
[Req 3.1.8-EP]	The app shall not waste the device's battery.
[Req 3.1.9-EP]	The app shall not waste the device's memory, and have no **memory leaks**.
[Req 3.1.10-EP]	The app shall not be taxing on the device's **CPU**.
[Req 3.1.11-EP]	The app shall have an options menu allowing the user to change settings.
[Req 3.1.12-PC]	The app shall never release any of the collected data to other locations or services without the user's explicit permission.
[Req 3.1.13-EP]	The app shall be able to run in the background.

3.2 Phone Application Front-End

Once meaningful information has been calculated, the app will be able to display relevant graphics and readings to the user. The general UI and look of any visual parts of the application should be pleasing to the eye and feel natural to use.

Table 3.2: Phone App Front-End Requirements

[**Req 3.2.1-EP**]	The app shall not have long loading times.
[**Req 3.2.2-EP**]	The app shall display a loading animation if loading time is necessary.
[**Req 3.2.3-PV**]	The app shall be simple and follow a standard UI practice.
[**Req 3.2.4-PV**]	Graphics or data displays shall be designed/animated to a high level, so that the app looks professional.
[**Req 3.2.5-PV**]	The app shall have a predetermined colour scheme.
[**Req 3.2.6-PV**]	The app shall contain clear and concise instructions for navigating and using the mask and app.
[**Req 3.1.7-EP**]	The app shall play a sound when the user begins a fitness test.
[**Req 3.1.8-PV**]	The app shall display warnings about wearing the mask on startup.
[**Req 3.1.9-EP**]	The app shall communicate visual indications of system failures to the user.
[**Req 3.1.10-PC**]	The app shall tell the user when a Bluetooth connection is established and when it is lost.
[**Req 3.1.11-EP**]	The app shall be able to display data in a relevant graph in a timely manner.

4 Hardware Requirements

The electronic components in our device's system are primarily concerned with obtaining measurements and data from the user's breaths during exercise, and transmitting those readings over Bluetooth to the user's mobile device.

Since *DeepBreath* is still in its early design phases, it is difficult to know specifics for the hardware/electronics requirements at this time. However, this section will describe some points we know to be necessary regardless of the components or designs that are decided on.

4.1 General Circuitry

Table 4.1: General Circuitry Requirements

[Req 4.1.1-EP]	The mask shall have insulated wires and components.
[Req 4.1.2-EP]	The circuitry shall have very low heat dissipation, so that it can be worn comfortably and safely on the face.
[Req 4.1.3-PC]	The device shall have an easily accessible mechanical switch that allows the user to turn the components on/off.
[Req 4.1.4-EP]	All wires shall be organized and secured tightly to the frame of the mask in order to have no loose parts.
[Req 4.1.5-EP]	The mask shall have a battery life that can last at least 30 minutes, or a long enough time to last a meaningful workout.

4.2 Sensors

Table 4.2: Sensors Requirements

[Req 4.2.1-PC]	The device shall include sensors for measuring the flow rate and CO_2 content of the user's breaths.
[Req 4.2.2-EP]	The sensors shall have relatively accurate measurements.

4.3 Microcontroller Module

Table 4.3: Microcontroller Module Requirements

[Req 4.3.1-PC]	The microcontroller shall be able to receive data readings in real-time from the sensors in the mask.
[Req 4.3.2-PC]	The microcontroller shall be able to interface with and transmit data to a nearby Android device that has a *DeepBreath* phone application installed, using Bluetooth.
[Req 4.3.3-EP]	The microcontroller shall send warnings and error signals to the user's mobile device when a failure or other error has occurred with the sensors.

4.4 Bluetooth

Table 4.4: Bluetooth Requirements

[Req 4.4.1-EP]	The Bluetooth module shall pair to the phone app quickly and seamlessly.
[Req 4.4.2-EP]	The mask's signal shall reach 20-25 feet like other Bluetooth devices.

5 Mechanical Requirements

As the experience of using *DeepBreath* relies so heavily on how it feels to wear the mask, we took that into account greatly for our Mechanical Requirements. We hope to make the mask accommodating to a wide array of sizes, and at the same time make efforts to ensure that it is comfortable and aesthetically pleasing in any part of the adjustment range. It is also imperative that the user's performance or ability to exercise are not hindered while wearing the mask.

5.1 Mask Structure

Table 5.1: Mask Structure Requirements

[Req 5.1.1-PC]	The face seal of the mask shall fully encase the user's nose and mouth.
[Req 5.1.2-EP]	The mask shall be lightweight and not bulky.
[Req 5.1.3-EP]	The straps shall secure the mask in place well in such a way that performing vigorous exercises such as running or jumping will not cause the mask to feel like it is bouncing.

5.2 Comfort

It is expected that *DeepBreath* will be worn and used during moderate to intense exercise sessions, while the user is performing shaky bodily movements. Comfort is an important priority, and we hope to make the mask as stable as possible and minimize any discomfort.

Table 5.2: Comfort Requirements

[Req 5.2.1-EP]	Wearing the mask shall not cause any significant discomfort or irritation to the skin.
[Req 5.2.2-EP]	The straps on the mask shall be easily adjustable.
[Req 5.2.3-EP]	Users shall be able to quickly and easily put on or take off the mask.
[Req 5.2.4-EP]	The parts of the mask that are in contact with the skin shall be padded.
[Req 5.2.5-PV]	The mask shall have various options for sizes of face seals to accommodate different people.

5.3 Aesthetics

Table 5.3: Aesthetics Requirements

[Req 4.3.1-EP]	The mask shall be aesthetically pleasing with the working components contained within a hard or soft shell.
[Req 4.3.2-EP]	The mask shall be as sleek as possible with an ideal size of an altitude training mask.

6 Safety Requirements

This section defines the safety standards for *DeepBreath*. Because it is a product with the intent of helping users improve their health, we take those usersâĂŹ safety very seriously: both when considering the components that go into the mask, and when defining the hazards that could go along with its use.

6.1 Operational Hazards Safety

Table 6.1: Operational Hazard Safety Requirements

[Req 6.1.1-PV]	The device shall come with warnings that it could restrict breathing (although the goal will be to restrict as little as possible) and recommendations for those who would be at a higher risk (children, asthmatic individuals) to use with caution.
[Req 6.1.2-EP]	The mask shall restrict the user's breathing as little as possible.
[Req 6.1.3-EP]	The mask shall obstruct the user's vision as little as possible.
[Req 6.1.4-EP]	All edges that can be found on the mask shall be rounded.

6.2 Electrical Hazards Safety

Table 6.2: Electrical Hazard Safety Requirements

[Req 6.2.1-PC]	The mask shall be very well grounded so that the user's face will never be in danger of electric shock.
[Req 6.2.2-EP]	Wires and other electronic components shall be well protected from sweat and moisture from breathing.

7 Sustainability Requirements

The sustainability requirements outlined here describe how Exotic plans to lessen the environmental impact of the device's life cycle, and how users can expect their mask to stand up to wear-and-tear. We hope to choose sustainable options whenever possible, and to create a product that has consumers impressed with its durability.

7.1 Efficiency

Table 7.1: Efficiency Requirements

[Req 7.1.1-EP]	The mask shall have a reasonable battery life.
[Req 7.1.2-PV]	There shall be some replaceable/exchangeable parts including the face seal, and straps.

7.2 Durability and Maintenance

Table 7.2: Durability and Maintenance Requirements

[Req 7.2.1-EP]	The mask shall be moisture resistant, but not waterproof.
[Req 7.2.2-EP]	The mask shall be rugged enough to survive reasonably hard drops/falls.
[Req 7.2.3-PV]	The mask shall work correctly for a year (under warranty) if taken care of properly.
[Req 7.2.4-EP]	The mask shall work in regular temperatures, 0-40 °C.

7.3 Environmental Considerations

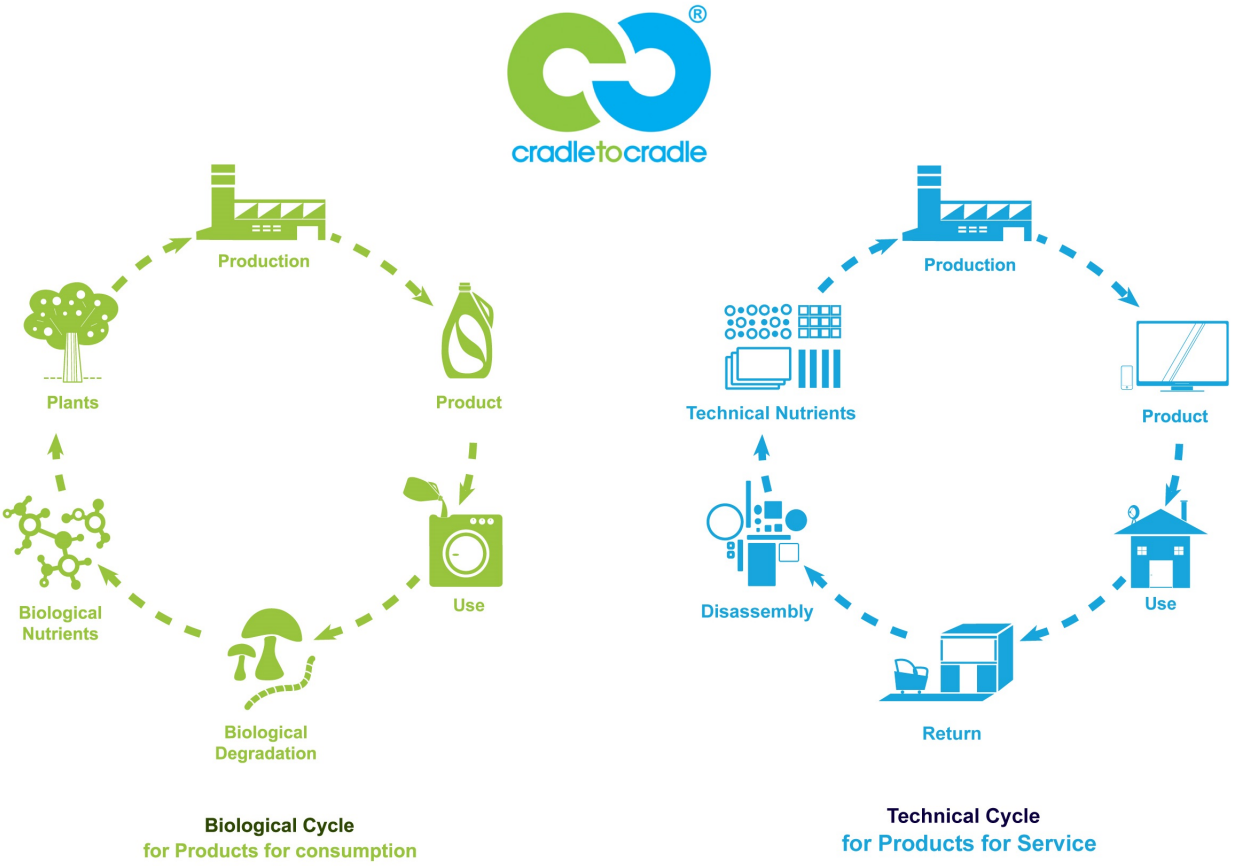

Figure 2: Cradle-To-Cradle Cycle

At Exotic, minimizing the environmental footprint during the design phases of our product is a top priority. We hope to follow cradle to cradle design principles whenever possible. Cradle to cradle design is an approach that attempts to mimic the zero-waste cycles found in nature, and apply them to the creation, disassembly, and reuse of technology. So, engineers aim to create products who's components can be completely reused at the end of the system's useful life, just like soil absorbing the nutrients of decomposing biological systems (plants and animals). [8]

Table 7.3: Environmental Requirements

[Req 7.3.1-PV]	The product shall have minimalistic packaging to reduce material usage.
[Req 7.3.2-PV]	The mask shall be partially made with recycled materials where reasonably priced and available.
[Req 7.3.3-EP]	The device shall not use any environmentally harmful chemicals or materials during design.

8 Engineering Standards Requirements

The engineering standards requirements define the specific public standards that *DeepBreath* will follow. They are primarily to protect the user from harm and information breaches.

8.1 Software Engineering Standards

Table 8.1: Software Engineering Standards

[Req 8.1.1-EP]	Development of the *DeepBreath* application software shall conform to the ISO/IEC/IEEE 12207:2017 technical processes, during the implementation and integration phases of the system. [4]
[Req 8.1.2-PV]	The *DeepBreath* application software shall conform to the ISO/IEC 29100 Standard for Data Security in regards to any personal identifiable information that may be stored or managed by our program. [5]
[Req 8.1.3-EP]	Coding standards and conventions in the application software shall follow the Google Java style for better maintainability and readability. [6]

8.2 Electronics Engineering Standards

Table 8.2: Electronics Engineering Standards

[Req 8.1.1-EP]	The electrical components shall be compliant with the RoHS directive, to ensure that hazardous or toxic materials are not used in the manufacturing of our device. [7]
[Req 8.2.2-EP]	The Bluetooth module of the device shall conform to the IEEE 802.15 Standard for Bluetooth communication. [8]
[Req 8.2.3-EP]	The device shall conform to the CAN/CSA-C22.2 NO. 61010-1-12 standards for safe measurement, handling, and control of our electronic componenets. [9]
[Req 8.2.4-EP]	The device shall conform to the IEEE P360 Standard for wearable consumer electronic devices, which is a series of standard specifications for defining technical requirements and testing methods for various functional areas of a wearable apparatus. [10]

9 Conclusion

Pro-athletes have had increasing access to high tech equipment which is used to analyze and optimize their workout by examining their fitness metrics. From the NHL to the NFL, the **combine** extensively uses these technologies to gain more insight into an athlete's fitness capabilities.

Equipment, such as these masks, are often offered exclusively to pro-athletes and nearly impossible for an average person to obtain. Most of these devices retail upwards of tens of thousands with the cheapest ones in the $5,000 range. Lastly, they are often complicated to use, with data displayed in a non-user-friendly way.

What Exotic aims to achieve with *DeepBreath* is a cost effective solution for the average person who wishes to see these metrics and track their fitness progress. *DeepBreath* can be split into 2 main sections: the mask and the app. Through the use of straps, light weight plastic, padding, and other materials, the mask aims to be as comfortable as possible without compromising its functionality. The mask's controller unit will send data from various sensors to the phone app via a wireless Bluetooth connection. The app will receive this serial data, process it, and display the information to the user in a meaningful and simple graphic. While there are products which offer similar capabilities, Exotic is hoping to market this mask at a significantly smaller price tag, making *DeepBreath* an affordable alternative for the every-day athlete.

10 References

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[2] "VO2 Master | Wearable", Vo2master.com, 2019. [Online]. Available: https://vo2master.com/. [Accessed: 27- Jan- 2019].

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[4] I. 12207:2017, "ISO/IEC/IEEE 12207:2017", ISO, 2019. [Online]. Available: https://www.iso.org/standard/63712.html. [Accessed: 2- Feb- 2019].

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[10] "P360 - Standard for Wearable Consumer Electronic Devices - Overview and Architecture", Standards.ieee.org, 2019. [Online]. Available: https://standards.ieee.org/project/360.html. [Accessed: 2- Feb- 2019].

Appendix A: Acceptance Test Procedure

Functional System Acceptance Test Procedure

Tester Name:		Date:	
FUNCTIONAL SYSTEM TEST			
Electronics Requirements			
Relevant Requirement(s)	Procedure	Result	Comments
Req. 4.1-3	Mask turns on/off when power button is pressed.	Pass ☐ Fail ☐	
Req. 4.1-5	Mask's battery lasts for at least 30 minutes.	Pass ☐ Fail ☐	
Req. 4.3-2	Mask controller is able to pair to a mobile device via Bluetooth.	Pass ☐ Fail ☐	
Data Collection, Transfer, and Display			
Req. 3.1-1	Phone app is able to receive breath readings in real-time.	Pass ☐ Fail ☐	
Req. 3.1-2 Req. 3.1-11	User shall be able to view meaningful fitness level metrics on the phone.	Pass ☐ Fail ☐	
Req. 3.1-3 Req. 3.1-10	Phone app pairs to mask via Bluetooth, and app displays an indication that a successful connection has occurred.	Pass ☐ Fail ☐	
Req. 3.2-1	App runs generally smoothly and does not crash.	Pass ☐ Fail ☐	

Usability and Comfort Acceptance Test Procedure

Tester Name:		Date:	
USABILITY AND COMFORT SYSTEM TEST			
Nose and Mouth Seal Requirements			
Relevant Requirement(s)	Procedure	Result	Comments
Req. 5.1-1	Seals correctly, with no air escaping through the sides.	Pass ☐ Fail ☐	
Req. 5.1-2 Req. 5.2-1	User feels comfortable when wearing the mask.	Pass ☐ Fail ☐	
Req. 6.1-2	Athlete can breathe through the mask without difficulty.	Pass ☐ Fail ☐	
Straps and Mask Positioning Requirements			
Req. 5.2-2	Straps can be adjusted enough to accommodate the athlete.	Pass ☐ Fail ☐	
Req. 5.2-1	Straps do not irritate the athlete's ears, hair, or otherwise.	Pass ☐ Fail ☐	
Req. 5.1-3	The mask is held in place adequately and does not interfere during vigorous exercise.	Pass ☐ Fail ☐	

Appendix B: Proof-Of-Concept Requirements

In the proof-of-concept prototype, we aim to the implement the core functionalities involving the physical components of *DeepBreath*. Namely, these include the the actual wearable mask and the electronic components within it responsible for measuring breath data and transmitting them over Bluetooth. The phone application software will be relatively simple in the PoC design phase, with its capabilities being limited at most to being able to receive the data over Bluetooth. Completion of user interface design and measurement calculations will be focused on in the following phase. The table below lists the requirements that will be included in the proof-of-concept prototype for the device.

Table 10.1: Requirements for Proof-Of-Concept Prototype

[Req 2.1.1-PC]	*DeepBreath* shall be able to calculate and measure the user's VO_2 max.
[Req 3.1.3-PC]	The app shall use the Bluetooth capabilities within the phone to pair with the mask.
[Req 3.1.6-PC]	The app shall be compatible with Android devices.
[Req 3.1.7-PC]	The app shall at minimum target and be compatible with-devices that are of version number Android 8.0 (API level 26).
[Req 3.1.12-PC]	The app shall never release any of the collected data to other locations or services without the user's explicit permission.
[Req 3.1.10-PC]	The app shall tell the user when a Bluetooth connection is established and when it is lost.
[Req 4.1.3-PC]	The device shall have an easily accessible mechanical switch that allows the user to turn the components on/off.
[Req 4.2.1-PC]	The device shall include sensors for measuring the flow rate and CO_2 content of the user's breaths.
[Req 4.3.1-PC]	The microcontroller shall be able to receive data readings in real-time from the sensors in the mask.
[Req 4.3.2-PC]	The microcontroller shall be able to interface with and transmit data to a nearby Android device that has a *DeepBreath* phone application installed, using Bluetooth.
[Req 5.1.1-PC]	The face seal of the mask shall fully encase the user's nose and mouth.
[Req 6.2.1-PC]	The mask shall be very well grounded so that the user's face will never be in danger of electric shock