February 7, 2019
Craig Scratchley
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Burnaby, BC V5A 1S6

Re: ENSC 405W Requirement Specification for UniLoq

Dear Dr. Scratchley:

The attached document provides the high-level requirement specification for the implementation of the U-Loq. With this system, UniLoq aims to prevent the plague of bicycle theft through a cost-effective and intelligent bike lock.

The U-Loq will use a two-part system of a smart bike lock and a small GPS tracker to ensure that any stolen bicycle can be retrieved by its owner. Whenever the bike lock portion of the system is broken or cut the owner will receive a notification with the real-time GPS location of their bike, which will allow their bike can be recovered and remain in their possession.

The requirements document will specify the functions and standards to be met in all three deliverable stages of development, which includes proof of concept, engineering prototype, and the final product. This document will firstly introduce the product and provide a high-level overview of the expected main functionality. The product will then be broken down into requirements that must be met at every deliverable stage to produce the full vision of U-Loq. The last portion of the document will be dedicated to the standards that must be met to sell the final product in Canada.

The UniLoq is comprised of the following six upper year engineering students with varied experience and specialties: Miguel Fernandez, Charles Chang, Jason Liu, Jameson Roy, Haotian Ye, and Zuo Xiong. Together this team will produce deliverables that meet all requirements and matches at every step the product this document details. UniLoq can be contacted directly for any questions or comments at cca214@sfu.ca.

Regards,

Jameson Roy

REQUIREMENTS SPECIFICATION FOR UNILOQ

Team 4

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Abstract

Bicycle theft is a rampant problem throughout Canada, with thousands of bikes being stolen in major cities each year. Having the highest number of reported bike thefts per capita in 2015, Vancouver has a considerable issue. [1] There have been several attempts to help solve this problem in the past, and two common approaches are bicycle registries and smart locks. While the former has resulted in a significant reduction in bike theft in the past few years, it remains that the number of bicycles stolen per year is in the thousands. Smart locks, on the other hand, have not made a sharp difference yet. Whether it be due to price or actual usefulness, the adoption of the smart bicycle locks has not been significant.

The U-Loq is UniLoq's attempt at changing that. The U-Loq is a smart bike lock that aims to be considerably lower cost than alternatives while still having compelling features such as GPS functionality, cellular communication, and area risk assessment. With these qualities, the U-Loq aims to have widespread adoption and ultimately have a significant effect on the reduction of bicycle theft in Canada.

This document provides a specification of the functional and non-functional requirements of U-Loq that must be met during its development. First, a more detailed high-level overview is given of the system, which includes an in-depth analysis of the problem. The requirements are then organized into their respective scope, namely general, performance, software, electrical, mechanical, appearance, and environmental/safety. Each of the requirements is further labeled according to its associated deliverable: proof of concept, engineering prototype, and the final product, thus providing a detailed guideline throughout the development of the U-Loq.

Table of Contents

Table of Figures

Table of Tables

1 Introduction

1.1 Background

The invention of the bicycle has changed the way people travel since the early nineteenth century. It is a relatively lightweight and fast means of travel. As biking is known as a healthy and environmentally-friendly activity, there is an increasing number of people traveling around the city by bike. In 2013/2014, an estimated 7.0 million people reported that they had cycled in the past 3 months, up from 6.5 million in 1994/1995. [2] However, cyclists are facing a severe issue: bike theft. Square One Insurance shows that the bike thefts are increasing, Figure 1 Reported bike thefts data [1]. Most of the bikes that were stolen were secured with a bike lock, which indicates traditional bike locks cannot protect bicycle thoroughly.

Figure 1 Reported bike thefts data [1]

Focusing on the problem pointed out above, UniLoq has decided to fight against the bike theft by making a smart bike lock called U-Loq. This smart bike lock can detect if the lock is broken by someone. If so, the bike lock system will send the notification with GPS location to the user's mobile device to alert the user his/her bike might be stolen. The GPS module will continually report the current position to the user to help them retrieve their stolen bicycle or contact appropriate authorities to catch the bike thief.

1.2 Scope

This document outlines the system overview, product requirements, and specifications. The product requirements are classified in different categories by stages. All the product requirements must be met to ensure the functionality of the final product. Also included is a test plan for assuring the final product meets the outlined standards.

1.3 Intended Audience

The intended audience of this document is UniLoq company members, technicians, and developers specifically, as the requirements are for the members who in charge of designing, producing and testing the product. To guarantee that the outcome matches what we want, members who are responsible for developing it must know the requirements and specifications.

1.4 Classification

The three stages of development with which deliverables are expected are defined as follows. The Proof-of-Concept prototype (C) is a prototype displaying the main features of the technology and will be presented at the end of ENSC 405W. The Engineering Prototype (P) will show off the full functionality and abilities of the system and should not be missing any essential features. Lastly, the Final Product (F) will deliver a fully complete and marketable version of the U-Loq to be presented at the end of ENSC 440.

The requirement list will use the following naming system below:

<Section>. <Subsection>. <Requirement Number>-<Development Stage>

Encoding	Development Stage
C	Proof-of-Concept
P	Engineering Prototype
F	Final Product

Table 1 Classification encoding

2 System Overview

U-Loq is a sophisticated and comprehensive anti-bike-theft integrated system, which is designed for bike owners to provide the highest security level for their bike.

Without sacrificing either practicality or beauty, the U-Loq is approximately 20cm tall, 11cm wide and 14mm in depth (thickness), with 2 Kg weight. The system combines a traditional steel bike lock with a built-in control/feedback communication system, which will physically detect the status of bike lock by a series of sensors. The only action users need to take off are attaching the U-Loq to the bike and locking it. The U-Loq will automatically update the real-time information to the user's mobile device if it is cut. The self-alarm system is embedded into U-Loq will trigger in case of it being cut if the user so chooses.

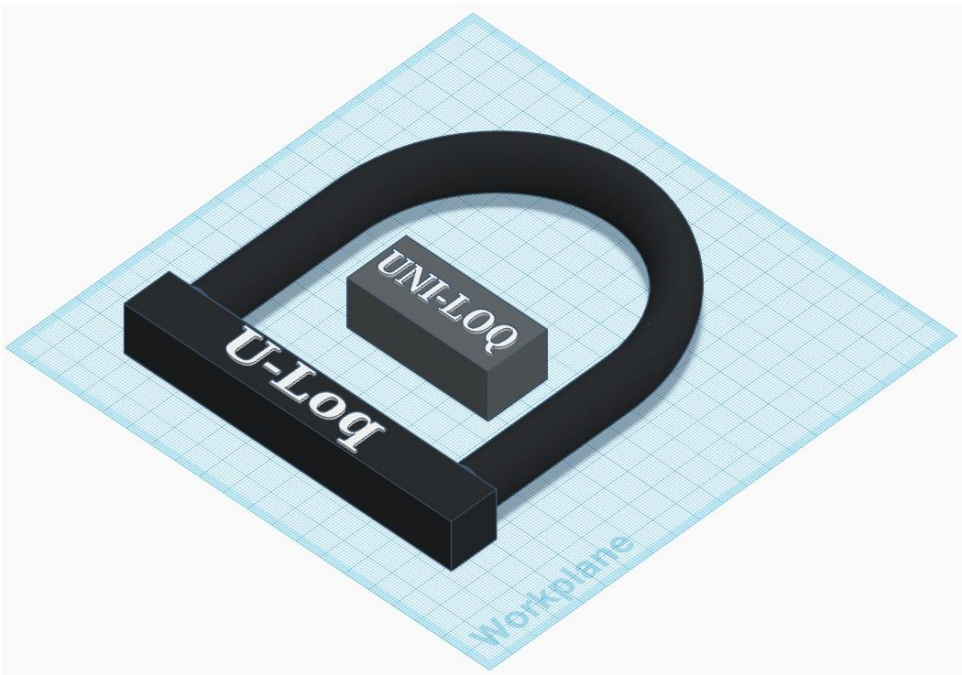

Figure 2 Concept design picture

Figure 3 System block diagram shows the concept design for U-Loq. This bike lock achieves a high-level of portability, reusability, practicality, and security in its purpose of bike protection. With this U-Loq system, the real-time status and location will be transmitted to the user's mobile device. The U-Loq will precisely provide a real-time map of bike location, battery status notification, and bike lock physical status notification to the user to ensure comprehensive control of the bike.

The U-Loq is a system comprised of two parts: the bike lock body, and a GPS tracker system. The bike lock body appearance is the same as that of a standard bike U-lock. However, it has a sensor built-in that can recognize if the lock is damaged or forced open in some way. Further, the lock body has a BLE (Bluetooth Low Energy) which is a remarkably low power Bluetooth unit that transfers the lock status to the communication system. The primary functionality of the bike lock body is to secure a bike and to monitor any attempted breakage. As for the communication system, it has more units built in such as a BLE, GSM, GPS module and a microcontroller. The system regularly monitors the bike lock body and verifies if the lock is in intact condition. If so, the communication system will remain in low power mode. I.E., it will ask the GSM and GPS module to sleep. However, if the bike lock body acknowledges the communication system, the system will wake up in a high-power mode, activate the GSM and GPS module to send the notification to the user and receive GPS data from the satellite. Therefore, it communicates with the lock body and the user. The GPS tracker system will be hidden in/on the bike to prevent damage.

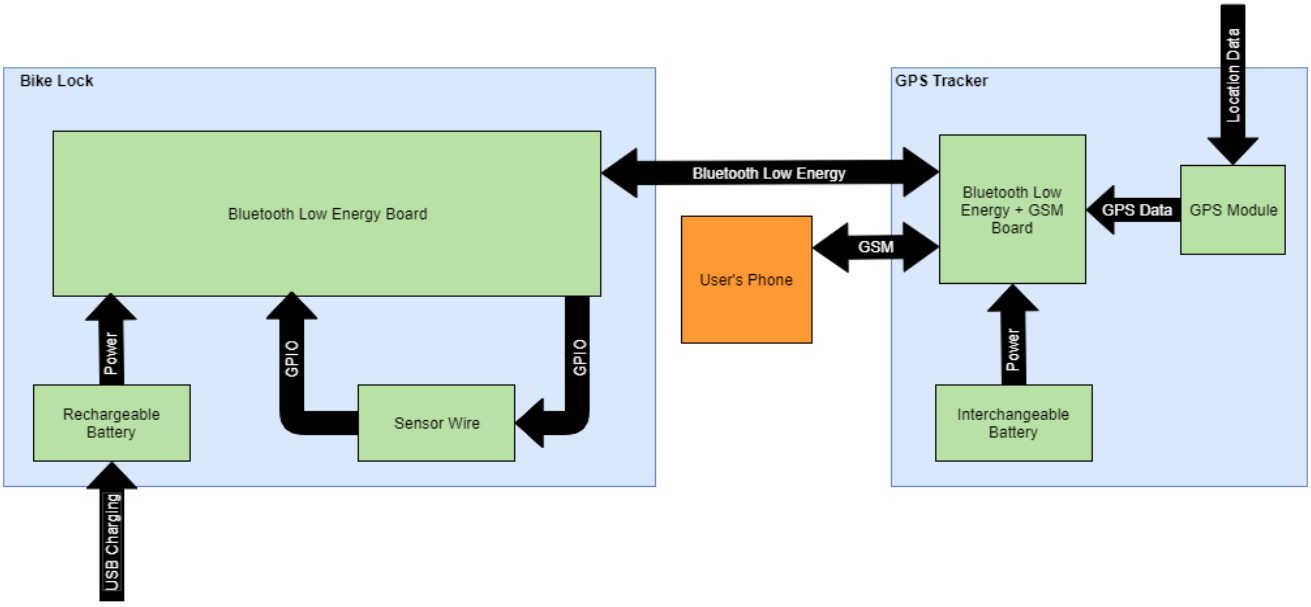

Figure 3 System block diagram

An Android app is designed for communication/information handling. U-Loq will represent the real-time notification effectively and directly. After data been collected by the terminal devices (bike lock and GPS tracker), all the information will be decoded and transmitted to this app through GSM.

The U-Loq is a reliable, small and powerful device that will prevent or track any thief attempting to steal the bike. Further, U-Loq will significantly decrease the crime rate regarding bike stolen/lost, with an affordable price to all public individuals, which is the project objective.

3 General Requirements

This section details the general requirements for the system which includes Bike Lock requirements, GPS Tracker requirements and system requirements. The general requirements will focus on the function and consumer-facing features of the product and are necessary for describing the product's functionality at the highest level.

3.1 Bike Lock Requirements

General requirements that involve the U-lock bike lock portion of the design will always be referred to as "Bike Lock" for the rest of the document.

Identifier	*Requirement Description*
3.1.1-C	Bike Lock must recognize when it is being broken or disarmed
3.1.2-C	Bike Lock must be unlockable by key
3.1.3-C	Bike Lock must be able to recognize when it is being armed/locked
3.1.4-P	Bike Lock must not be heavier than 4kg
3.1.5-P	Bike Lock must be able to work in a temperature range from -30 to 50 degree Celsius.
3.1.6-F	Bike Lock must have an alarm so that nearby people can notice a theft happens
3.1.7-P	The alarm must have the ability to be disabled/enabled by the user

Table 2 General bike lock requirements

3.2 GPS Tracker Requirements

General requirements that involve the GPS tracking portion of the design referred to as "GPS Tracker" in the rest of the requirements. It is the component used to communicate with the Software and will be hidden somewhere on the bike.

Identifier	*Requirement Description*
3.2.1-C	GPS Tracker must send notification via the cellular communication to software when broken
3.2.2-P	GPS Tracker must have a GSM module that can send and receive data via cellular network
3.2.3-P	GPS Tracker must enter high power mode even if the Bike Lock portion is destroyed
3.2.4-P	GPS Tracker must be able to work at temperatures between -30 and -50 degrees Celsius

Table 3 General GPS tracker requirements

3.3 System Requirements

General requirements that pertain to the system (GPS Tracker and Bike Lock together) and cannot be defined separately.

Identifier	*Requirement Description*
3.3.1-C	Bike lock system must enable GPS signal when broken
3.3.2-F	Bike lock system must be cheaper than a normal full-size bike
3.3.3-P	Bike lock system must be hard to be disabled by force, I.E. the GPS module must be hard to break or find in the bike
3.3.4-P	System communication via cellular network must be independent of functioning Bike Lock and GPS tracker modules
3.3.5-C	Bike Lock and GPS Tracker must be separate modules

Table 4 General system requirements

4 Performance Requirements

Requirements in this section will pertain to expectations on how the different systems are meant to perform. These will contain numerical information that will outline the accuracy and speed necessary for the U-Loq to function as expected.

Identifier	*Requirement Description*
4.1.1-P	GPS Tracker must be accurate within 10 meters horizontally
4.1.2-P	GPS Tracker must enter high power mode within 20 seconds of the bike lock being broken
4.1.3-P	Software must alert the user of the Bike Lock being cut within 30 seconds
4.1.4-P	The Bike Lock alarm must be loud enough to be clearly heard from at least 50m away
4.1.6-P	The Bike Lock alarm must activate within 5 seconds of the lock being cut
4.1.7-P	GPS Tracker must update the Software with location data at least every 15 seconds when in high power mode
4.1.8-P	Software must boot up completely within 5 seconds on any device it is available on

Table 5 Performance requirements

5 Software Requirements

Requirements in this section categorize the functionality of the software application for the user's phone. That is the user interface for the U-Loq system. It is necessary that requirements are well defined, so a clear picture of the final product does not become distorted. Some requirements for the software, such as performance, may appear in other categories because this category is made exclusively for the main functionality of the software.

Identifier	*Requirement Description*
5.1.1-P	Software must include a real-time map of bike location
5.1.2-P	Software must be able to receive notifications
5.1.3-F	Software must know the risk of bike theft within a 2km radius of the bike lock's location
5.1.4-F	Software must notify the user if the bike lock has been armed in a high-risk area
5.1.5-P	Software must be accessible to the user on their phone
5.1.6-F	Software must notify the user when the GPS Tracker's battery is low
5.1.7-F	Software must notify the user when the Bike Lock Battery is low
5.1.8-C	Software must notify the user when the Bike Lock is broken
5.1.9-F	Software must be able to poll remaining battery life of Bike Lock
5.1.10-F	Software must be able to poll remaining battery life of GPS Tracker
5.1.11-P	Software must be able to poll power mode of Bike Lock
5.1.12-P	Software must be able to poll power mode of GPS Tracker
5.1.13-P	Software must have the ability to enable/disable the Bike Lock alarm

Table 6 Software requirements

6 Electrical Requirements

For the electrical requirements, it is mainly made up of three parts which are the battery, GPS module, and circuit design. The circuit design will be investigated more deeply in the prototype stage. Since the product is portable, there is a need to make sure the battery is rechargeable and has a long life. The battery also needs to be light and fit in the enclosure. For the GPS Tracker, it is essential that the circuit design guarantees it stays in low power mode when bike lock is not cut and enters high power mode when it is damaged. This requirement helps with the power consumption problem of the system. As with the circuit design, the microcontroller for the GPS Tracker will be decided upon in the prototype stage. However, there is still a need to make sure the battery has the same voltage as the microcontroller need for input. The size and weight of the microcontroller also will be a significant factor.

6.1 Bike Lock Requirements

Electrical requirements involving the "Bike Lock" portion of the system.

Identifier	*Requirement Description*
6.1.1-P	Bike lock may use built-in lithium-ion battery
6.1.2-P	Bike lock must charge via USB battery charging
6.1.3-F	Bike lock must notify the Software when the battery is low
6.1.4-F	Bike lock specification must follow the Canadian Electrical Code/Standards for regulation purposes
6.1.5-P	Bike Lock must have a low power mode when it is unlocked
6.1.6-P	Bike Lock must have a high-power mode when it is locked
6.1.7-F	The connector of lithium battery must allow for easy user replacement
6.1.8-P	Bike lock battery must be able to last at least 24 hours while locked
6.1.9-C	Bike lock battery charging time from 0% to 100% cannot exceed 3hours
6.1.10-C	Battery of bike lock must have the same voltage as the microcontroller input voltage

Table 7 Bike lock electrical requirements

6.2 GPS Tracker Requirements

Electrical requirements involving the "GPS Tracker" portion of the system.

Identifier	*Requirement Description*
6.2.1-P	GPS Tracker must have a low power mode when the Bike Lock is not broken
6.2.2-P	GPS Tracker must have a high-power mode when the Bike Lock is broken
6.2.3-F	GPS Tracker's battery must last at least 24 hours in high power mode
6.2.4-P	GPS Tracker must have a replaceable battery
6.2.5-F	GPS Tracker must notify the Software when its battery is low
6.2.6-F	GPS Tracker's battery must last at least 5 months in low power mode
6.2.7-F	GPS Tracker lithium battery size must fit the enclosure so that it can be easily hidden in/on the bike
6.2.8-C	GPS output signal must not exceed the current limit of microcontroller GPIO pins.

Table 8 GPS tracker electrical requirements

7 Mechanical Requirements

Mechanical requirements will deal with the physical portions of the system that do not require the electronics or batteries. These requirements are necessary for outlining possible use cases for the product (e.g., usage in wet or dusty environments), as well as design constraints implied by the material choices. It mostly involves the physical enclosures of the devices, such as what they are made of and the function expected from said enclosures. More cosmetic descriptions of the case may also be found in appearance requirements in the next section.

Identifier	*Requirement Description*
7.1.1-P	The electrical enclosure may use any easily shaped material, such as cardboard, plastic, or styrofoam
7.1.2-F	The lock must be made of steel
7.1.3-F	The steel enclosure must be painted with weather resistant paint
7.1.4-F	GPS Tracker must be dust resistant
7.1.5-F	GPS Tracker must be water resistant
7.1.6-F	Bike Lock must be water resistant
7.1.7-F	Bike Lock must be dust resistant

Table 9 Mechanical requirements

8 Appearance Requirements

These appearance requirements describe the portion of the system that the users will see. Some of the appearance requirements will have a functional effect, but the purpose of these requirements is to make sure that the final appearance of the product is agreed upon by the entire development team. Furthermore, as with the General Requirements, it is necessary to have these requirements when describing the product at the highest level.

Identifier	*Requirement Description*
8.1.1-F	The colour of the lock may use any colour (black for first product)
8.1.2-P	Bike Lock must follow a U-lock form factor
8.1.3-F	Bike Lock must appear without any obvious smart features or smart feature labeling
8.1.4-F	Software must appear sleek and simple with minimal UI elements
8.1.5-F	GPS Tracker must have a slim and discreet form factor

Table 10 Appearance requirements

9 Environmental and Safety Requirements

Requirements in this section are to make sure that environmental concerns and safety remain a priority. The pressures of creating a product make it all too easy to cut corners in terms of safety and the environment but making them a deliverable ensures that they are not lost or skipped in the pursuit of a great product. It is in line with UniLoq's commitment to safety and protecting the environment with low energy, smart and secure solutions.

Identifier	*Requirement Description*
9.1.1-P	Bike lock must use a rechargeable battery
9.1.2-P	Bike lock must not made by any harmful material but material that can be recycled or degraded
9.1.3-C	The electrical component must not pose fire or explosive risk under normal usage conditions.
9.1.4-F	There should be no sharp edge on the lock for safe handling.
9.1.5-P	All electronic components must be operated under the normal condition in case of electrical hazard

Table 11 Environmental and safety requirements

10 Engineering Standards

The following tables are the list of engineering standards that will be kept. Since the U-Loq system will require electronics, mechanical, and wireless communication system, it is imperative to follow engineering standards to ensure the safety and the reliability of this product. Moreover, one of the core philosophies of the team is to make a product that has the least negative impact on the environment as possible and thus environmental standards have also been included to ensure these goals are met.

10.1 Electrical

Standard	*Description*
IEC TR 62513:2008	Safety of machinery - Guidelines for the use of communication systems in safety-related applications [3]
IEC 62061:2005	Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems [4]
IEC 61192-1:2003	Workmanship requirements for soldered electronic assemblies - Part 1: General [5]

Table 12 Electrical engineering standards

10.2 Mechanical

Standard	*Description*
ISO/TTA 5:2007	Code of practice for creep/fatigue testing of cracked components [6]

Table 13 Mechanical engineering standards

10.3 Wireless Communication Standards

Standard	*Description*
IEEE 802.15.1	Standard for wireless Bluetooth communication [7]
IEEE 802.21	Standard for GSM communication [8]

Table 14 Wireless communication engineering standards

10.4 Environmental Standards

Standard	*Description*
ISO 13475-1:1999	Acoustics -- Stationary audible warning devices used outdoors -- Part 1: Field measurements for determination of sound emission quantities [9]
ISO 15270:2008	Plastics -- Guidelines for the recovery and recycling of plastics waste [10]

Table 15 Environment engineering standards

11 Proof-of-Concept Test Plans

The test plan listed below will be used to acceptance test the proof-of-concept prototype before it is presented at the end of ENSC 405W.

Software		
Test Case	***Pass/Fail***	***Comments***
1. Up to date GPS data is displayed in some manner when a bike lock is broken		
2. Notification alert system is functional		
3. Notification alert system is functional when is bike lock is broken		
4. Bike Lock power control system is functional		
5. GPS Tracker power control system is functional		

Table 16 Software test plans

Electrical		
Test Case	***Pass/Fail***	***Comments***
General Circuit		
1. Circuit are operational at temperature range -30 to 50 degree Celsius.		
2. The electrical components pose no risk of fire or explosion under any use conditions		
3.GPS module is in low power mode when the bike lock is not cut, vice versa.		
Battery		
1. Input Voltage from the lithium-ion Battery		
2. Has same voltage between battery and microcontroller input		
3. Charging time of the bike battery is appropriate for its power output		

Table 17 Electrical test plans

Functional		
Test Case	***Pass/Fail***	***Comments***
General		
1. Bike lock recognizes the disconnection of the lock		
2. Bike lock recognizes the connection of the lock		
3. The lock cannot be open without a key		
GPS System		
1. GPS system is enabled when the lock is opened		
2. GPS connects to cellular communication when the lock is opened		
3. GSM module able to send data via the cellular network		
4. GSM module able to receive data via the cellular network		

Table 18 Functional test plans

12 Conclusion

The requirements outlined in this document specify the boundaries within which the U-Loq will be built. The U-loq is designed as a tool to help all bike riders, many of whom have suffered from bike theft, fear bike thieves, and are dejected by the lack of effective means to retrieve their bikes. Further, U-Loq and its GPS tracking functionality can considerably decrease the incidence rate of bike theft in Vancouver and other cities in the world.

UniLoq believes that U-Loq will be affordable to all income groups no matter if they own a standard or fancy bike. The team will try its best to control the budget of this project and let U-Loq become one of the most cost-effective smart bike locks in the market.

We will also develop more features that other ordinary bike locks products do not have such as sending the bike lock status through Bluetooth technology or communication with users through GSM module.

As a company, we aim and strive to make our products leave a mark on consumers and the market. The U-Loq will be unique because of its user-friendliness, cost-effectiveness and sleek form factor. It will remarkably enhance the safety of locking up bikes and protect bike riders from the potential of losing their cherished bike. Our company will construct a quality product that meets all the requirements outlined in this document.

13 List of References

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