

March 28, 2019
Craig Scratchley
School of Engineering Science
Simon Fraser University
Burnaby, BC V5A 1S6



Re: ENSC 405W Design Specification for UniLoq

Dear Dr. Scratchley:

The attached document provides the project proposal which gives a thorough overview of the U-Loq system. 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 concealed GPS tracker to ensure that any stolen bicycle can be retrieved by their 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 to be recovered and remain in their possession.

The purpose of this document is to fully explore the broad feasibility and market for the U-Loq. This document will first explore the scope and risks of taking on this project as well as the benefits. The market for the project will be examined and the overall cost of the project of the U-Loq detailed. Lastly, the plan for the development of the U-Loq will be set forth, and the UniLoq team will be introduced with their skills and roles outlined. Through these sections, the proposal document will leave the reader convinced of the feasibility of the U-Loq and that it can be financially successful.

The UniLoq team 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 is consistent with the product this document details. UniLoq can be contacted directly for any questions or comments at cca214@sfu.ca.

Regards,

A handwritten signature in black ink, appearing to be "JR" or similar initials, written in a cursive style.

Jameson Roy



PROJECT PROPOSAL FOR UNILOQ

Team 4

Miguel Fernandez

Charles Chang

Jameson Roy

Haotian Ye

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Jason Liu

Revision 1.0.0



Executive Summary

Uniloq is proposing the U-Loq system as a unique approach that tackles one specific but very prevalent problem in many cities around the world - bike theft. Our system can essentially be described as a “smart lock”, with the goal of leveraging modern technologies to provide greater security and recoverability compared to existing anti-theft solutions. Specifically, the U-Loq system goes above and beyond conventional methods by having the ability to detect when it is broken or opened, at which point the user is alerted on their mobile phone via our mobile application. In addition to this, our mobile application gives the user the ability to track the location of their bicycle using a map updating in real-time. In turn, this higher level of security will deter future potential bicycle thieves and provide peace of mind to all bike riders everywhere.

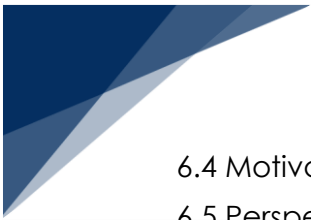
The system is separated into two modules - a robust smart U-lock and a reliable GPS-tracking/system-monitoring device. These work together to recognize nearly all instances of bicycle theft and provide a way for the user to retrieve their stolen bike or contact appropriate authorities to do so. The U-lock will contain smart technology, being able to recognize when it is opened or cut. Fundamentally, it will function just like any other U-lock, allowing for ease of use through an established standard. The GPS tracker will be hidden discreetly, possibly being masked as a generic reflector to prevent being disarmed or broken. It is responsible for sending data over the cellular network to the user. This setup will provide the necessary GPS, Battery, and overall system status information to keep the user informed about his/her U-Loq, which will all be displayed intuitively on our custom U-Loq mobile application.

The U-Loq system is overall simple, but quite an ambitious project. We aim to have a product that can be sold to the masses using simple but reliable technologies. Many details have gone into conceptualizing a product that satisfies the goals stated above, all while remaining accessible and cost-effective. Found in this proposal document is an outline of the prototype design, market analysis, risk/benefit analysis, and project schedule. Also introduced is the UniLoq team, carefully selected in order to thoroughly and reliably complete all outlined tasks. A proof of concept prototype will be completed in April 2019, and after securing the necessary funding, work on a final prototype is expected to be completed in August.



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Glossary

| Term | Definition |
|-------------|---|
| Abus | A bike lock company. |
| Arduino | Arduino is an open-source hardware and software company, project and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices and interactive objects that can sense and control both physically and digitally. [1] |
| BLE | Bluetooth Low Energy. A Bluetooth module that can operate in remarkable low energy mode. |
| CAGR | Compound Annual Growth Rate |
| GPIO | General Purpose Input Output. It is one of the most common input output interfaces on hardware for communications. |
| GPS | Global Positioning System. A system that can locate current position by three or more satellites signal. |
| GSM | Global System for Mobile communications. It is the protocols for second-generation (2G) digital cellular networks |
| Kryptonite | A bike lock company. |
| OnGuard | A bike lock company. |
| SparkFun | SparkFun Electronics is an electronics retailer. |
| UNV-SIM868 | UNV-SIM868 is a GPS/GSM/BT built-in development board with a SIM868 processing chip. |

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 . 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 [3]

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 Risks

The risk associated with the bike lock on the user end is minimal. There is no significant risk of fire and explosion on electronics hardware. However, on the designer and manufacture side, there are risks of market acceptance and during the manufacturing process. In this section we will be focusing on the risk of associating with designing and manufacturing.

1.2.1 Two Part System Communication

The U-Loq is based on a two-part-system, a bike lock and a GPS tracking module. If there is a communication malfunction between the two modules, the bike lock system will not able to perform the job as expected. To overcome and mitigate the risk, the user will be informed when there is a connection error between the two systems and a warning message will be sent before the lock is broken.

1.2.2 Market Acceptance

There is a potential risk that the U-Loq is not going to be accepted by the consumers, since there are finished products in the marketing, and UniLoq is new to the market. The goal of the U-Loq is to sell a lower price, better mobile application solution to the consumers.

1.2.3 Bike Lock Manufacturing

In order to design a bike lock that is strong enough to resist the power tool from breaking the lock, the bike lock needs to be built as sturdy as possible. The bike lock is going to have electronics embedding in the lock itself. The process of building or modifying an existing bike lock poses risks during the assembly process from the involvement of power tool, welding, and other machine tools. To ensure safety during the assembly process, UniLoq will receive proper training and consult lab technician before the final product assembly.

1.2.4 General Use Case

The U-Loq system is designed to detect when the lock is broken and send the GPS location to the user through the GPS module. However, if the thief knows the existence of the bike lock system, it might break the bike lock case or the GPS instead of the lock. Thus, there is a risk of GPS not able to transmit the GPS location of the bike to the user. UniLoq is constantly in the process of finding solutions to hide the GPS module, with the current solution being to disguise it as a rear bike reflector.



1.3 Benefits

Bike theft is one of the most prominent problems facing big cities around the world, Vancouver is no exception. The goal of the U-Loq system is to provide security and peace of mind to the bike owner. Moreover, with cost-effective design and a reliable system, the two-part bike lock design is one of a kind in the market. Although there are risks associated with the system, UniLoq believes the benefits of the bike lock system outweighs the risks. In this section, the benefits of the U-Loq system will be explored.

1.3.1 Reliability

The bike lock is going to provide reliable service to the user from the mobile app to the bike lock itself. The bike lock is going to be built to withstand a power tool and perform under different weather conditions.

1.3.2 Innovation

Although there are all kinds of bike locks out on the market. The two-part bike lock system is one of a kind. With the adaptability of the bike lock system, the bike lock module and the GPS module could perform as an individual system. Moreover, the bike lock system can be applied to other motor vehicles such as the motorcycle and scooter.

1.3.3 Cost Effective

With the utilization of off-the-shelf parts, UniLoq can cut cost from the prototype to the final product stage. The cost of the product will be affordable to the average consumer. Moreover, the subscription service for the GPS function will allow UniLoq to bring in profit after the initial sale of the product.

1.3.4 Security

Having your bike stolen is one of the most heart-breaking things that could happen to the bike owner when each bike can cost up to thousands of dollars. The goal for the U-Loq is to give the bike owner a peace of mind by knowing where their bike is at all time and alert them if the bike is stolen so they can get it back.



1.4 Scope

The scope of this capstone project includes the design and creation of a prototype for U-Loq. This prototype includes two portions that are GPS tracker and bike lock itself. When the bike lock is broken or opened, it must have the ability to send this information to GPS tracker through Bluetooth Low Energy. In the meantime, GPS tracker should wake up from a low power mode and be activated to send real-time GPS data and general U-Loq status to users by the functionality of GPS and GSM module. Users can always check GPS, battery and U-Loq status on the custom smartphone app.

The prototype will achieve the following functionality using:

- ESP32 Thing to detect when U-Loq is broken or opened
- A Lithium-Polymer battery to charge the ESP32 Thing
- UNV-SIM868 to send GPS data and GSM text to users
- Arduino Nano to control UNV-SIM868
- An interchangeable 16430 Lithium-Ion battery to charge UNV-SIM868
- The smartphone app is written in Kotlin

The prototype's size is constrained by the size of the U-shaped lock that will be used. It is because UniLoq will insert ESP32 Thing in a U-shaped lock from the third party for the final product.

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.

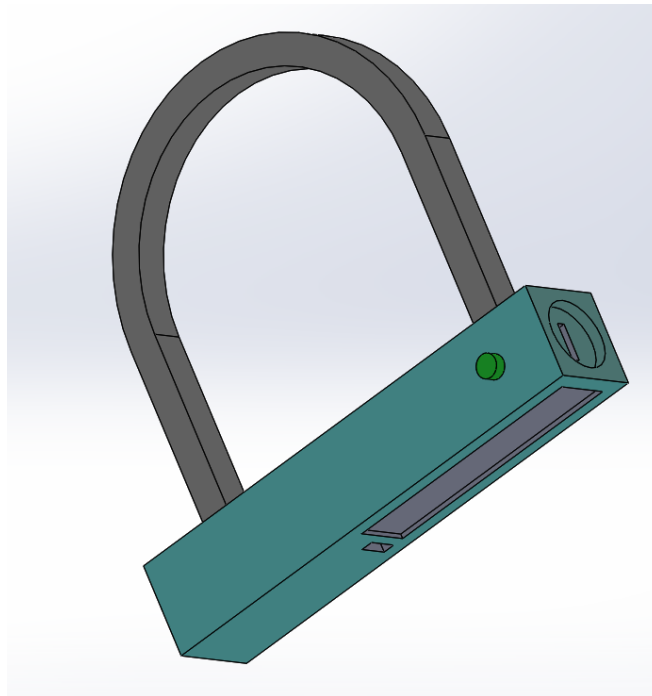


Figure 2 Concept design picture

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., the GPS module will 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.

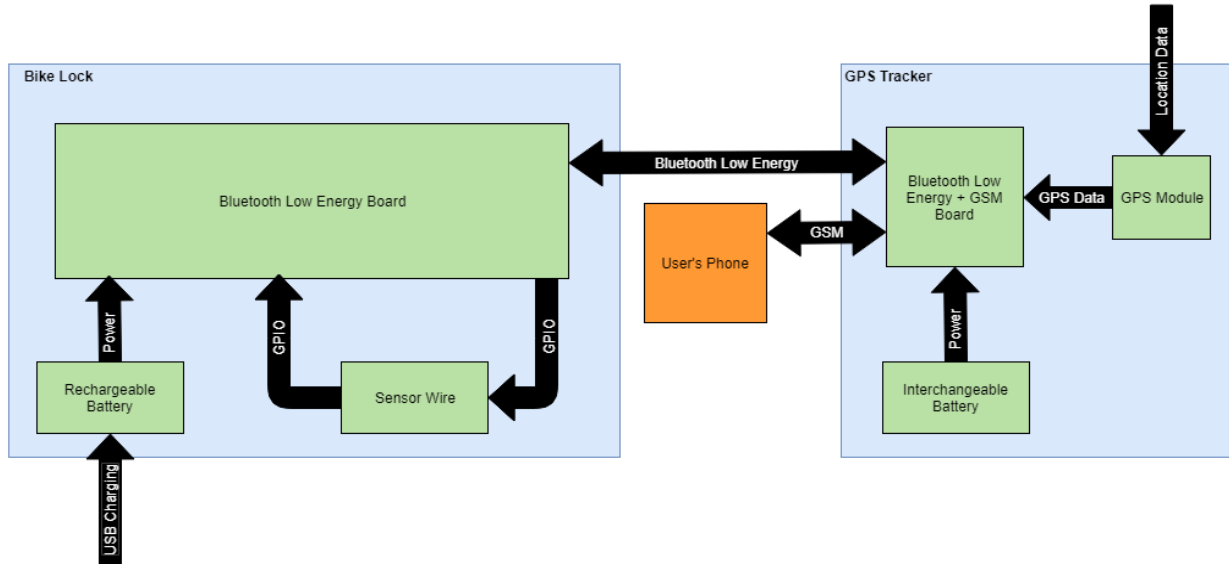


Figure 3 System block diagram

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 Market Research

3.1 Bike Theft

The first way to gauge the size of the market for the U-Loq is by looking at just how many bikes are stolen every year. According to a report by Square One compiled in 2016, “The total number of bike thefts in these cities [Toronto, Vancouver, Calgary, Montreal, Edmonton and Winnipeg] increased 31% between 2014 and 2015” [4]. This shows a trend of increasing bike theft in Canada where, “Vancouver continues to experience the highest rate of bike thefts at 513 thefts per capita [100, 000 people]”. These numbers indicate a real problem with current security methods in Canada but expanding to a global scale the problem can be much worse. A good example is in China where bike-sharing services have grown in popularity and “one start-up folded after 90 percent of its bikes were stolen [5]. In places where bike sharing is becoming more popular theft will rise as more bikes are introduced and companies will want to protect their bikes the best they can.

3.2 Bike Lock Market

According to the guide found in “*The 6 Best Bike Locks in 2019*”, the bike lock market has the “big three: Abus, Kryptonite and OnGuard” [6]. These three are the most trusted names in bike locks which makes breaking into the market with any new standard bike lock difficult. In sectors that involve security such as bike locks brand name trust goes a long way with consumers and most purchasing guides tend to only recommend these brand names. Out of the big three in bike locks, it appears only Abus offers any smart bike lock solution with their U-Lock 440 Alarm and U-Lock 770A SmartX™ [7]. Both solutions just offer alarming and smartphone integration which does not have nearly as many security features as the U-Loq.

3.3 Smart Bike Lock Market

While the U-Loq would be competing in the bike lock market, due to the lack of current smart solutions from the big brands it falls more specifically into the smart lock (also known as e-lock) market. According to the Smart Bicycles Market by Components assembled by Infoholic Research, the “e-bike lock system is expected to grow at a CAGR [Compound Annual Growth Rate] of 8.0% during the forecast period to reach revenue of \$123.1 million by 2023” [8]. The research helps demonstrate a growing market, but it is also a very young market with many of the current players coming from the crowd-funded project and less established brands.



3.4 Target Market

There are rooms for UniLoq to pursue one of two options for bringing the U-Loq to market. The first is to bring the U-Loq final product to an established bike lock vendor in order to leverage their resources and brand to mass produce and get an edge in the market. This option would be preferable as it would allow for the U-Loq to find success much more easily and avoid the complex and difficult process of mass manufacturing. If interest is not found from an established brand, then UniLoq can bring the U-Loq to market and compete in the much younger and less established smart lock market. While this option is less preferable and more difficult the U-Loq will find success due to its superior security features and user-friendly design.

4 Cost and Funding

4.1 Project Costs

The projected costs of building our product are based on component orders from common electronics distributors (For example, Lee's Electronics). The prices calculated below will cover the cost of prototype and an approximate cost of the final product. These prices do not include labor costs, consumable costs, production equipment costs, and lease/building costs.

| Component | Description | Price (CAD) |
|-------------------------|---|-------------|
| ESP32 Thing | Development Board in bike lock | \$27 |
| UNV-SIM868 | Development Board in GPS tracker | \$10 |
| Arduino Nano | Microcontroller that control UNV-SIM868 | \$45 |
| USB-TTL | UNV-SIM868 to computer | \$10 |
| Sample Bike Lock | Bike lock for prototype | \$6 |
| Lithium-Polymer Battery | Charging ESP32 Thing | \$10 |
| Lithium-Ion Battery | Charging UNV-SIM868 | \$12 |
| Total | / | \$120 |

Table 1 Prototype Parts and Cost

The cost of prototype design is 120 dollar that is very close to what we expect before we start this capstone project. There will be no big difference between the cost of the prototype and final product except for the bike lock part. We will buy a third-party U shape bike lock for our final product design. Consequently, the total cost of our final product will be approximately 150 dollars including U shape bike lock, and this total cost maybe will increase when some components are missing during the design process.

4.2 Funding

Sources of funding for the capstone project are still being explored. The main choices we are looking for are IEEE Student Project Funds and Engineering Science Student Endowment Fund. We also consider alternatives such as Wighton Engineering Development Fund. Applications for these funds will be finished as soon as possible so that we can have a solid understanding of our financial plan in the future. Finally, any expenses on components will be distributed equally among all group members. These expenses are treated as an investment for our prototype and final product design.

5 Project Planning

In this section, the major project milestones are provided and explained. These milestones provide concrete and necessary indicators toward project completion. The Gantt Chart below illustrates the planned timeline of the project and its respected milestones.

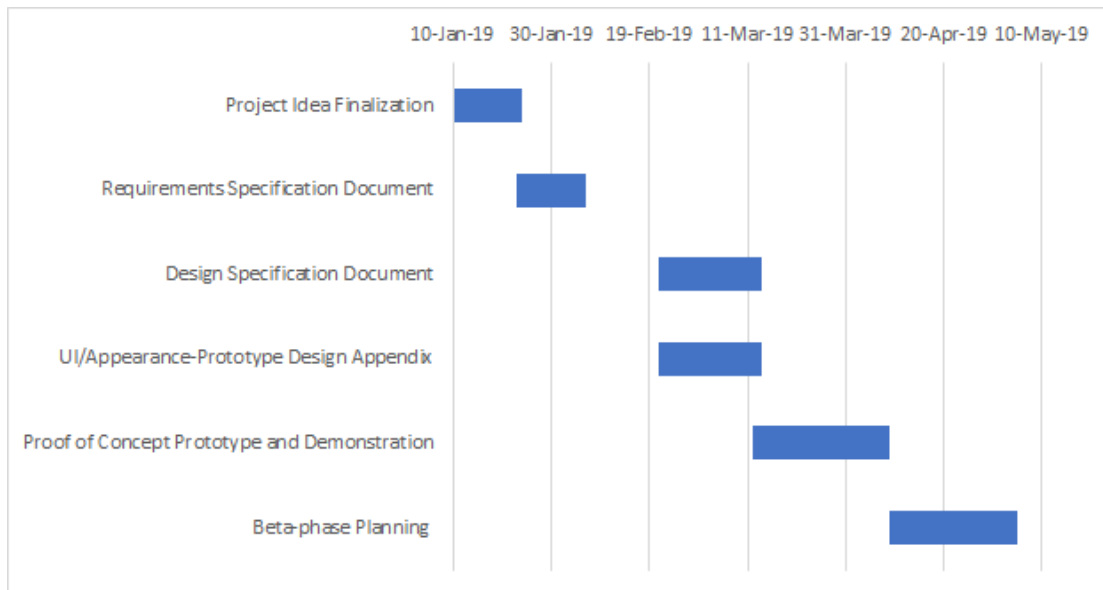


Figure 4 Gantt chart

5.1 Project Idea Finalization

The purpose of this milestone is to systematically and democratically choose a project based on viability. Our team takes time, individually, to conceptualize ideas. We then meet weekly to discuss and debate the viability of our respective ideas and using democratic voting. Ideas are eliminated one by one. Consultation sessions with various Professors and Teaching Assistants are also planned in order to assist in discerning which ideas are practical. This milestone has a timeline of 2 weeks and is to be completed on January 24, 2019

5.2 Requirements Specification Document

The purpose of this document is to outline the basic functional and non-functional requirements of the product, as well as its respective modules. We provide a high-level description of product expectations throughout the entire design process – that is, we outline the requirements for the Proof of Concept, Engineering Prototype, and Final Product. This document also provides official engineering standards that are to be followed. All of this is to create a guideline for the development of the project that can be referred to throughout the entire process. This milestone has a timeline of 2 weeks and is due on February 6, 2019.



5.3 Design Specification Document

The purpose of this document is to provide an in-depth overview of the design decisions of the project as a whole and its discrete modules. We provide justification for a design decision, as well as any considered possible alternatives. This document further solidifies the viability of the project by making the team provide thoughtful insight through concrete solutions as opposed to just simple, higher level ideas. This milestone requires extensive research and thus has a timeline of 3 weeks and is due on March 14, 2019.

5.4 UI/Appearance-Prototype Design Appendix

This milestone is an accompaniment to the Design Specification Document. It provides expectations regarding the outcomes of various stages of design specifically through details regarding the proper/expected use of the system. This milestone also provides proper insight on design and UI choices to prevent error, ensure safety, and maximize usability and accessibility. As it accompanies the milestone above, it shares the same timeline and completion date of March 14, 2019.

5.5 Proof of Concept Prototype and Demonstration

This milestone is the main end-of-term outcome of the project design. The goal is to provide a tangible product that deliverers on the promises outlined in both the Requirements and Design Specification documents. This proof-of-concept prototype is meant to solidify the viability of the design as well as build the confidence of potential investors. It provides basic functionality as well as a clear framework on which a more polished final product can be built upon. The timeline for this milestone is 4 weeks and is to be completed on April 9, 2019.

5.6 Beta-phase Planning

The purpose of this milestone is to provide a concrete plan regarding the next phase of the project design. After completing the Proof of Concept and obtaining proper funding, there is a clear point to build upon for the next phase. It is important to thoroughly inspect all the details and feedback regarding the project so far and create a plan that maximizes the integrity and usability of the next major version of the product. This milestone has a timeline of 26 days and is to be completed on May 5, 2019.

6 Company Details

Growing up in Burnaby, British Columbia, Canada, UniLoq is a brand-new technology company that provides expertise in the bike security solution, including bike protection plan, customized bike lock, GPS solution, and IoT lock extension. As a young and enthusiastic team in the wireless communication industry, UniLoq always focuses on humanized applications and impeccable systematic products and service.



With UniLoq protection plan and 6 members of the UniLoq engineer, all your security requirements will be met.

6.1 Company Information and contact details

Business Name: UniLoq, Inc.




Business Address: 8888 University Dr, Burnaby, BC, Canada

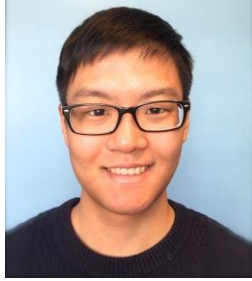
Phone: 778-836-7170

Total number of Employees: 6

Primary Line of Business: Industry security application

6.2 Our team

| Team Member | Experience/Skills Overview |
|--|--|
|  <p>Jameson Roy jamesonr@sfu.ca Chief Operating Officer</p> | <p>Jameson is a fifth-year computer engineering student at SFU. His main experience is in firmware development coming from a job as Co-op Firmware Developer at NETGEAR. This experience provided skills in low energy and smart technology design. Jameson also has experience in QA testing and scripting through a co-op work term at Icron Technologies. This industry experience along with skills developed through five years at SFU will be invaluable in the development of the U-Loq.</p> |
|  <p>Miguel Fernandez miguelf@sfu.ca Chief Executive Officer</p> | <p>Miguel Fernandez is a fifth-year Computer Engineering student at SFU. He has worked as a Firmware Developer Co-op at NETGEAR. In this position, he specialized in mobile hot-spot development, gaining experience in C/C++ as well as building familiarity with technologies such as GSM and Wi-Fi. Miguel also has experience in QA testing and technical support, working in the public sector for the Canadian Grain Commission as a Technical Support Assistant. Appointed as Chief Executive Officer, Miguel will be in charge of overseeing the project as a whole.</p> |
|  <p>Jason Liu yangjiel@sfu.ca Chief Technology Officer</p> | <p>Jason Liu is a fifth-year Computer Engineering student at SFU. He has worked on hardware testing, schematic automation, kernel configuration, embedded Linux driver implementation and frontend backend development which involved multiple programming languages such as C/C++, Python, Typescript, PHP, etc. In this project, he will oversee the firmware implementation and testing. With the knowledge across several domains like hardware, embedded software, and web, he is assigned as the Chief Technical Officer of the company and will be providing technical guidance.</p> |



Charles Chang

cca214@sfu.ca

Chief Communication
Officer

Charles Chang is a fifth-year Electronics Engineering student at SFU. With the previous co-op in hardware testing and machine learning, Charles has strong fundamental both in software and hardware. In this project, Charles will be focusing on the development of hardware electronics and machinal design. Moreover, along with strong communication skill, Charles has been assigned to Chief Communication Officer, with the goal of the market our product to the general public and maintain good relation to our customers.



Haotian Ye

haotiany@sfu.ca

Chief Financial Officer

Haotian Ye is a fifth-year Electronics Engineering Student at Simon Fraser University. He enjoys research, working with electronics, and programming in C++ and Python. He will be working in GPS tracker portion and helping with hardware design. Haotian has been appointed Chief Financial Officer (CFO) of Uniloq, where he will use his knowledge of finance to oversee the funding and costs of U-Loq.



Zuo Xiong (Eric)

zuox@sfu.ca

Chief product Officer

Eric is a 5th-year system Engineering student with interests in mechanical design and hardware development. With the industrial work experience of RMA repair support engineer in BSM technologies Ltd, Canada and Baseband engineer in ZTE Telecommunication Corp., China under his belt, Eric will apply all solid skills and technical knowledge, with consistent effort into UniLoq.

Table 2 Company members and overview



6.3 Workforce

The UniLoq develop team comprises of six senior year engineering students with varied experience and specialties, and the number is expected to increase in the following year as product volume extension.

6.4 Motivation

The UniLoq concept was developed in Jan. 2019 which intended to be a unique approach that tackles one specific but very prevalent problem in many cities around the world - bike theft. The objective of our team is to build a higher security standard e-lock with IoT extension compare to traditional lock.

6.5 Perspectives

We care everything that UniLoq supposed to care. We believe UniLoq will be a turning point of the way people move, daily life and lifestyle.

We are UniLoq, we are not just a bike lock equipment provider, but also a technology company that focuses on engineering and industrial innovation.



7 Conclusion

As the trend of increasing rate of bike theft worldwide, our team at Uniloq decides to design a product 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. U-Loq and its GPS tracker can considerably decrease the incidence rate of bike theft in Vancouver and other cities in the world.

Different from other ordinary bike locks, U-Loq will provide more functionalities and features in order to decrease the incidence rate of bike theft and let users have a better user experience. Users can always check real-time GPS information, battery capacity and general U-Loq status on smartphone app designed by Uniloq.

As a company, we aim and strive to make U-Loq leave a mark on consumers and the market. U-Loq will be unique because of its user-friendly user interface, cost-effectiveness and sleek form factor. We believe that U-Loq will remarkably enhance the safety of locking up bikes and protect riders from the potential of losing their cherished bikes.



8 List of References

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