TRIWAVE SYSTEMS

July 21, 2019

Dr. Craig Scratchley
Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
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RE: ENSC 405W/440 Project Proposal for Arkriveia Beacon

Dear Dr. Scratchley and Dr. Rawicz,

The following document contains the Project Proposal for the Akriveia Beacon - The Indoor Location Rescue System created by TRIWAVE SYSTEMS. The Akriveia Beacon focuses on locating personnel trapped in buildings during small scale disasters such as fires and low magnitude earthquakes. This is achieved by incorporating a combination of advanced Ultra-wideband radio modules and microcontrollers to create a dependable indoor positioning system using trilateration methods. We believe our system allows search and rescue operator to safely and reliably locate victims during an emergency or disaster. Therefore, lowering the search a rescue time and increasing the chances of rescue and survival for trapped victims.

In the attached project proposal provides an overview of the Akriveia Beacon system as well as present the scope, risks, and benefit analysis of the product. It will then examine current market and potential competitions and discuss project budget, funding and cost considerations. Furthermore, an overview of the timeline and planned schedule for the Alpha and Beta phases of this project is presented, and lastly, a brief introduction to the project team members will be provided.

TRIWAVE SYSTEMS is composed of five dedicated and talented senior engineering students. The members include Keith Leung, Jeffrey Yeung, Scott Checko, Ryne Watterson, and Jerry Liu. Coming from various engineering backgrounds with a diverse set of skills and experiences, we believe that our product will truly provide a layer of safety and reliability to search and rescue operations.

Thank you for taking the time to review our project proposal document. If there are any further questions or comments, please direct them to our Chief Communications Officer Jeffrey Yeung at zjyeung@sfu.ca

Sincerely,
Jerry Liu
Chief Executive Officer

Enclosed: Project Proposal for the Arkriveia Beacon

SFU

TRIWAVE SYSTEMS

ENSC 405W

Akriveia Beacon

Project Proposal

Team 5

21/07/2019

Project Team

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Submitted to

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Executive Summary

A major concern during disaster search and rescue operations involving large and complex commercial buildings is the process of locating potentially trapped victims. In current conventions, there are no reliable methods of accurately locating trapped victims for first responders, as commercial building structures are large and complex by design. The Akriveia Beacon by TRIWAVE SYSTEMS focuses on creating an safe and dependable solution for indoor location tracking with the objective of locating multiple trapped victims in complex urban environments with pin point accuracy. Such system will allow search and rescue operations to be carried out during small scale disasters such as fires and low magnitude earthquakes safely and efficiently, minimizing potential damages and casualties.

Utilizing various hardware, electrical and software components, the engineers at TRIWAVE SYSTEMS is aiming to create a solution that can accurately and reliably to locate and identify trapped victims within complex structures in near real time. By pinpointing the exact coordinates of any trapped victims associated with an ID tag, the search and rescue time for first responders can be minimized, which is critical in any disaster rescue operations. This is achieved by incorporating a combination of advanced Decawave Ultra-wideband radio frequency (RF) modules, Espressif ESP32 microcontroller units (MCU), data processing units (DPU), and reliable trilateration techniques to create a dependable real time indoor location positioning system.

This project proposal document provides a brief overview of the system architecture; perspective on current markets and potential competitions; discuss project planning; available budget, funding, and cost consideration; as well as an overview of the development team at TRIWAVE SYSTEMS. The proposal will cover the three phases of product development: Proof-of-concept (PoC) phase, Prototype phase, and Final Product phase.

TRIWAVE SYSTEMS is dedicated to creating a reliable and robust indoor location system designed to improve disaster search and rescue operations with human safety as the pivotal focus.

Glossary

DPU Data Processing Unit. 3, 11

ESSS SFU Engineering Science Student Society. 21

ETSI European Telecommunications Standards Institute. 11

FCC Federal Communications Commission. 11

GIL Global Indoor Location. 17

GPS Global Position Systems. 17

GUI Graphical User Interface. 9, 16

IC Integrated Circuit. 11

ID Identification. 8

MCU Micro-controller unit. 3, 9

PCB Printed circuit board. 10

PoC Proof of concept is the sample product assembled to explore project feasibility. 3

RF Radio Frequency. 3

RSSI Received Signal Strength Indicator. 8

SAR Search and Rescue. 17

SBC Single board computer. 11

ToF Time-of-Flight is a method for measuring the distance between a sensor and an object. 9

UDP User Datagram Protocol. 9

UWB Ultra wide band. 8, 11

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1 Introduction

Over the last couple of decades, urban centers around the world have faced substantial population growth. As a result, the number of large and complex structures in dense urban areas around the world is rapidly increasing. In Canada alone there are approximating 500,000 commercial buildings [1]. A large population combined with massively complex buildings in relatively dense areas leads to higher risk for damage and casualties in the event of a disaster. Due to increased urbanization and complexity of urban structures, search and rescue operations in indoor urban environments face various complications and uncertainties. According to Statistics Canada, an average of 135 fire related deaths occur within commercial structures each year from 2010 to 2014 [2]. In current practices, first responders know little about the situation until arriving on scene. Once responders are on scene, emergency management have to quickly evaluate the situation and plan for appropriate actions [3]. Assessments of the structure are conducted with readily available blueprints of buildings along with limited information of last known location of possible trapped victims, usually derived from witness reports. Situational data are created dynamically during this process and the actual rescue process heavily depends on the situational awareness of the first line of emergency response operators [4].

An important issue that must be considered is how emergency first responders should be dispatched inside the building in the event of a disaster in order to minimize search and rescue time as well as limit potential risk to first responders. In order to pinpoint locations of trapped victims quickly and accurately it is critical to have precise location data. Proper emergency planning and organization takes a substantial amount of time, and having additional accurate information on the locations of trapped, incapacitated or immobile personnel would improve first responders situational awareness which would then improve their own safety and possibly greatly increases the victims chances of rescue and survival. As such, the need for a distinct indoor positioning rescue system is crucial in getting fast and reliable information that allows first responders to be dispatched within buildings in the most optimal and efficient manner.

The Akriveia Beacon by TRIWAVE SYSTEMS focuses on improving the locating and rescue process of personnel trapped in buildings during or after small scale disasters such as fires and low magnitude earthquakes. This is done through a system of Ultra Wide-Band (UWB) Beacons and Identification (ID) tags for accurate, near real-time location of trapped personnel. Each ID tag uses a UWB transceiver module to communicate with the beacon system with similar UWB transceivers. Given the time between sending and receiving transmission data, the distance can be estimated via time of flight. The Beacons will then forward these distance estimations to a data processing unit using a private WiFi network where it will use trilateration methods to calculate the near real time location of each individual ID tag. The system design allows for multiple ID tags as well as more than three anchor beacons to provide more accuracy through redundancy, making it modular and extendable.

The following proposal will describe the details of the system architecture, project scope, risk-benefit analysis, budget and funding, discuss potential markets and competition, and provide an overview of the project planning and scheduling. Furthermore, a brief company profile will be provided to emphasize the skill sets and experience of each of the TRIWAVE SYSTEMS members to showcase the qualification of the engineers involved in developing the Akriveia Beacon System.

2 Project Overview

2.1 System Overview

The Akriveia Beacon indoor locating rescue system combines hardware, electrical, and software systems to detect and locate multiple occupants within a building during an emergency disaster situation. Each individual component of the system is developed separately in the Proof of Concept (PoC) phase, partially integrated in the Prototype phase and fully integrated in the Final Product phase.

A high-level system overview presents three Locator Beacons, an ID tag, a data processing unit, and a graphical user interface (Figure 1). Using the Time-of-Flight principle (ToF) which is a method for measuring distances between transceivers. Based on the time difference between the emission of a signal after being reflected by an object and its return to the sensor, the distance between a beacon and an ID tag can be estimated r[5].

The Locator Beacons transmit ultra-wideband (UWB) signals in the frequency of 3.5-6.5GHz to the ID tag to acquire a response. When the response returns back to the Beacon a ToF measurement is acquired. The ToF data captured by ESP32 microcontroller unit(MCU) will be forwarded to a portable data processing unit, a Raspberry Pi, via private WiFi network with User Datagram Protocol (UDP). Then the processing unit will calculate the distance and coordinates of the ID tags using a trilateration algorithm, then the coordinates results are displayed on a Graphical User Interface (GUI) for operators.

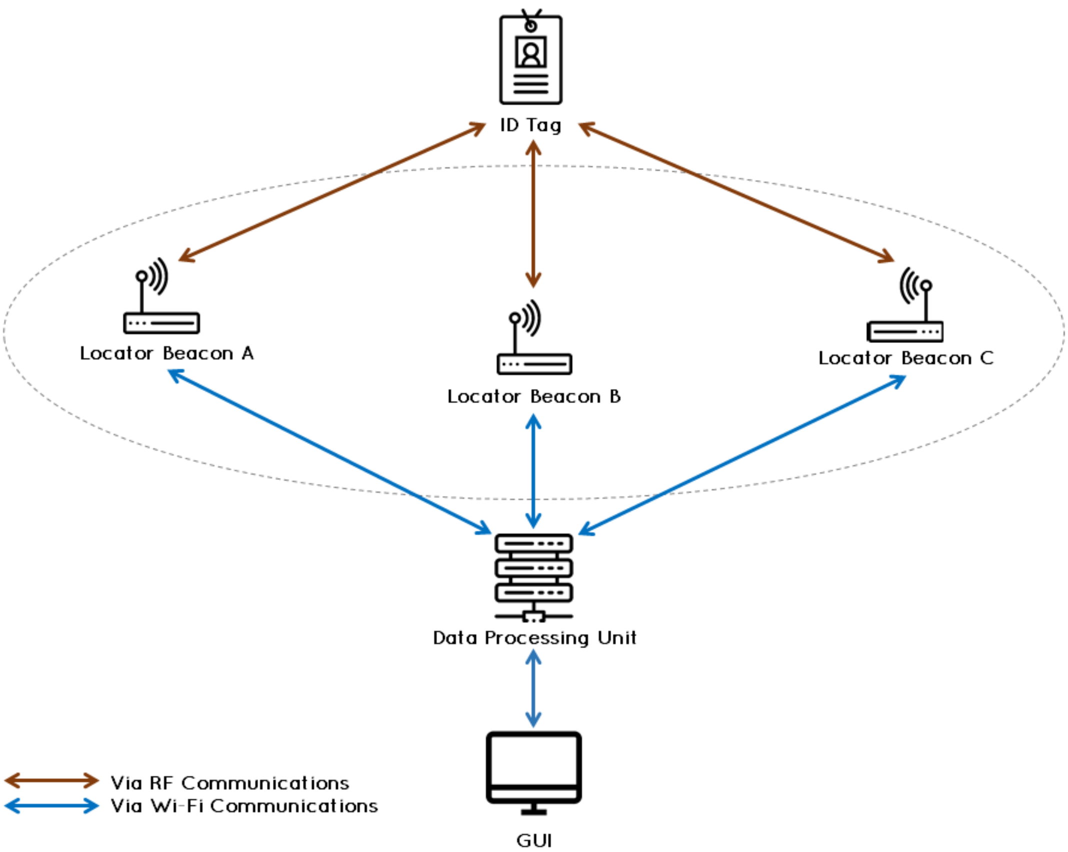

Figure 1: High Level System Layout

The final product will demonstrate the fully functional indoor rescue system that detects the location of the ID tags and displays it accordingly on a GUI. Here the of ESP32's WiFi modules for Beacon to DPU communications can be seen (Figure 2), as the Beacon will communicate via WiFi communication with the data processing unit. The WiFi network will be a closed private network meaning that the network is only share between beacons and the data processing unit to ensure security, reliability and stability. Furthermore, implementation of a RF harvesting circuit for charging the ID Tag device during deep sleep mode will occur throughout this stage. All the components of the systems will be fully integrated as a close-to-production product. Component circuits and PCB footprint will be minimized and proper casing will be made to house all electronics. The data processing unit will provide the user with a full GUI to interact with along with fully implemented features such as importable blueprints and system configurations.

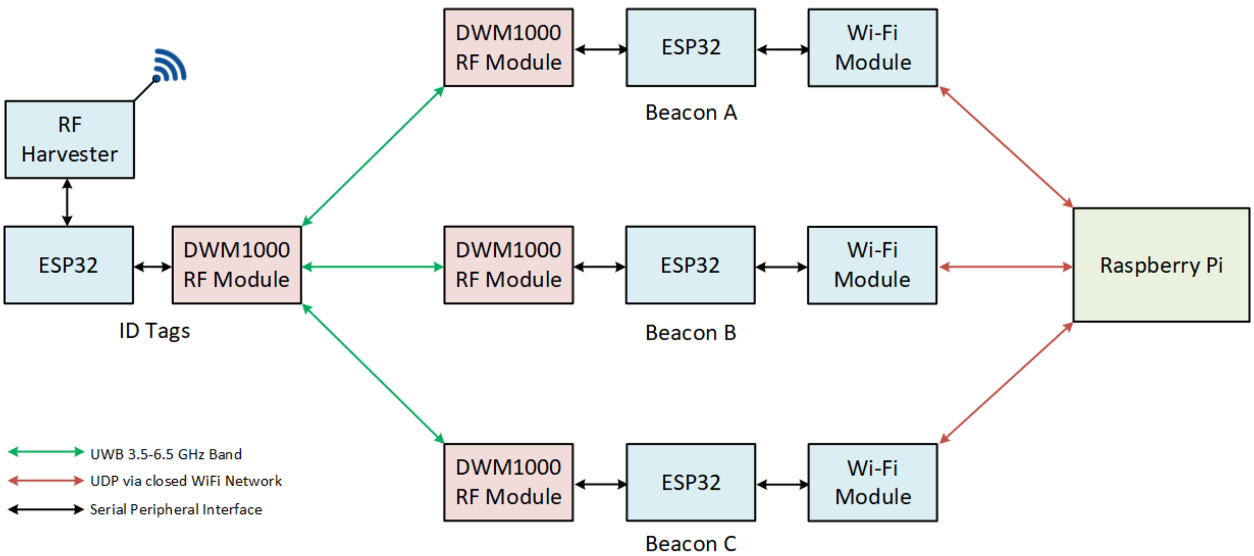

Figure 2: Final System Block Diagram

2.1.1 System Components

The Beacon and ID tags are composed of Decawave DWM1000 UWB module (Figure 3 right) and a Espressif ESP32 microcontroller (Figure 3 left). The ESP32 contains a Tensilica Xtensa LX6 microprocessor in both dual-core and single-core variations and includes a in-built antenna, power amplifier, low-noise receive amplifier, filters, and power-management modules. The DWM1000 is an IEEE802.15.4-2011 UWB compliant and FCC/ETSI certified wireless transceiver module based on Decawave's DW1000 IC [6]. This module is a combination of DW1000 IC, a built in antenna, power management system, and clock control for simple design integrations.

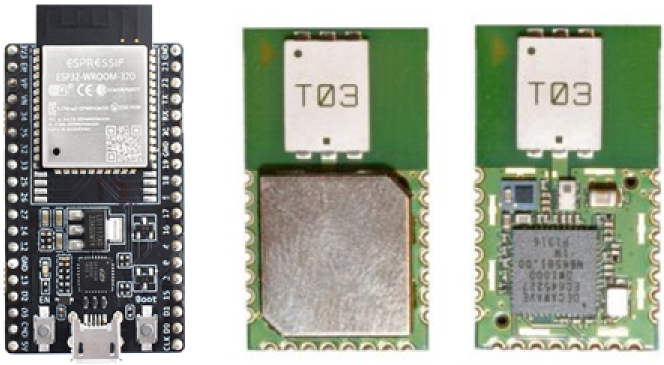

Figure 3: Left ESP32 [7], Right DWM1000

The Data Processing Unit is a stand alone single board computer (SBC). For the demonstration of this project a Raspberry Pi 3 B+ is used as the data processing unit (DPU) since it is an affordable and robust SBC, but the DPU in theory could be any electrical computer device that is capable of running a basic linux operating system; as the software stack for the DPU is designed to operate on any linux based system. The Raspberry Pi 3 B+ is affordable, portable, and designed with an Cortex-A53 processor, it satisfy the minimum requirements for the DPU.

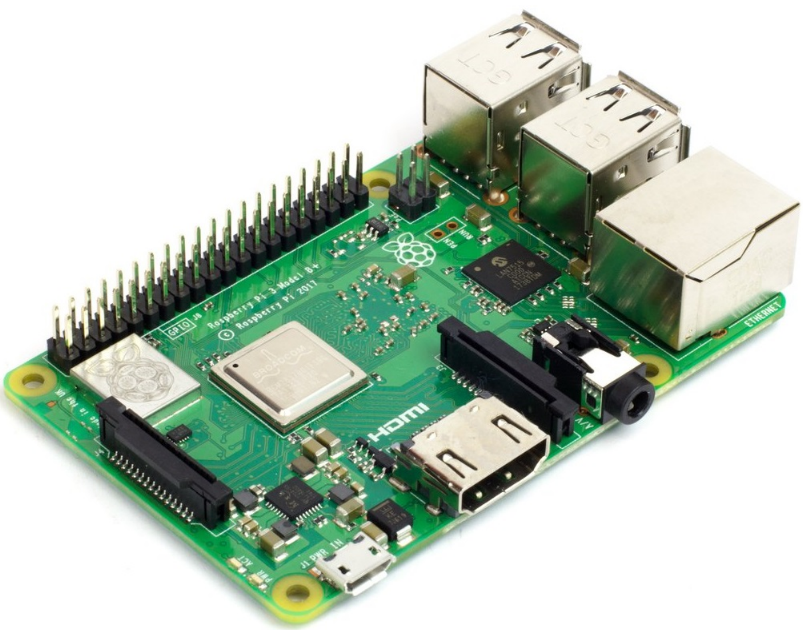

Figure 4: Raspberry Pi 3 B+ Model [8]

2.1.2 Trilateration Method

The Akriveia Beacon 2-D indoor localization solution determines the X-Y coordinates of ID tags using basic trilateration methods. The trilateration method follows a lateration scheme with absolute distances, which uses distance related metrics such as ToF to determine the distance between a sender and a receiver. In the case where there is a single beacon and ID tag, the distance between the two entities can be interpreted as the radius of a circle traced with the beacon centered as demonstrated in figure 5 with D is the distance between any given ID Tag and Beacon.

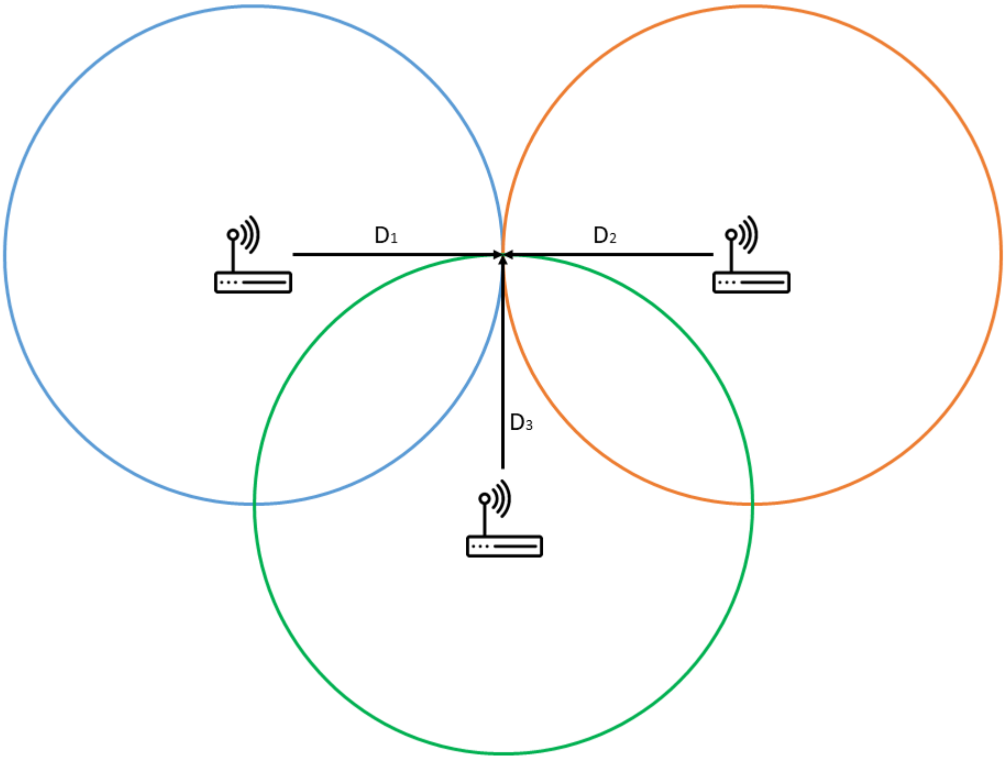

Figure 5: Trilateration Diagram

Such a circle takes on a standard mathematical form as shown in equation (1) below [9], where variables x_0 and y_0 are the 2-D coordinates of the beacon position relative to its environment, and r_0 is the distance between the beacon and the ID tag. Given the 2-D coordinates the three beacons and their individual distance with respect to the ID tag, three circles can be traced to form an intersection point at the location of the ID tag. Hence, three standard form circle equations are generated to form a system of equations with two unknowns as shown in equation (2). The solution to the unknowns, or the intersection coordinates of the ID tag can be obtained by solving the system in equation (2).

$$(x - x_1)^2 + (y - y_1)^2 = r_0^2 \tag{1}$$

$$\begin{aligned}(x - x_1)^2 + (y - y_1)^2 &= {r_1}^2 \\ (x - x_2)^2 + (y - y_2)^2 &= {r_2}^2 \\ (x - x_3)^2 + (y - y_3)^2 &= {r_3}^2\end{aligned} \tag{2}$$

2.2 Project Scope

Goal

The goal of the Akriveia Beacon system is to provide accurate and reliable indoor location tracking of trapping personnel during small scale emergency disaster in near real time. The location information will be complied and presented to aid first responders on locating trapped victims during any emergency disaster situations. By providing accurate location data of trapped victims, the search and rescue time for first responders can be drastically lowered, and therefore, limit first responder exposure to potentially dangerous environments and increase the chances of survival of trapped victims.

Justification

The Akriveia Beacon system must maintain critical functions under emergency disaster situations such as fires and low magnitude earthquakes. System components must design to be durable and initiative to use for all end users. Each beacon and ID tag must be designed to withstand various environmental factors such as high temperature, low visibility, and other dangerous factors. The users of the system must have some form of knowledge of the system prior to operating. Lastly, as an indoor tracking tag device the ID tags must be worn at all times by all personnel associated.

Assumptions

The Akriveia Beacon system must maintain critical functions under emergency disaster situations such as fires and low magnitude earthquakes (less than 6.9 on Richter magnitude scale). Each beacon and ID tag must be designed to withstand various environmental factors such as high temperature, low oxygen, fragile structural integrity, and other dangerous factors. The users of the system must have some basic form of technical and operational knowledge of the system prior to operating. Lastly, as an indoor tracking tag device the ID tags must be worn at all times by all personnel associated within the intended area of operations.

Deliverables

The Akriveia Beacon is designed as a system of anchor beacons and wearable ID tags composed of Espressif ESP32s MCUs and Decawave DWM1000 UWB transceiver modules. A minimum of three beacons are needed for trilateration to function. A portable data processing unit will also be part of the system and be implemented in Rust to create a layer of control and interaction between the users and the system. For the purpose of the demonstration a Raspberry Pi 3 B+ will be used as the DPU. In theory, any single board computer which meets the minimal specification can be used as the DPU.

Constraints

The system as a whole must remain operational throughout the event of a disaster as the search and rescue effort rely on information generated by the system. Each component of the system will need a battery backup to maintain functionality if the primary power source is unavailable. As an indoor location tracking system a tag device must be worn by personnel being tracked at all times while in proximity of the beacons. As wearable electronics, the size of the ID tags must be optimized in its design so it is ergonomical as an everyday carry item. Power consumption will be another important aspect to focus on as with all wearable electronics. To reduce maintenance costs the device battery must maintain charge over prolonged periods of time or have methods of wireless charging.

2.3 Risks

As a system that will operate in potentially dangerous environments during disasters the Akriveia Beacon system faces various boundaries, which can be a source of risk and thus potential risks and boundaries should be defined further.

Most common risks for this project are:

- **Cost Risk:** Typically escalation of project costs due to poor cost estimating accuracy and scope creep.
- **Schedule Risk:** The risk that activities will take longer than expected. Slippages in schedule typically increase costs and delay the receipt of project benefits, with possible loss of competitive advantage.
- **Performance Risk:** The risk that the project will fail to produce results consistent with project specifications.
- **Governance Risk:** Relates to board and management performance with regard to ethics, community stewardship, and company reputation.
- **Strategic Risks:** From errors in strategy, such as choosing a technology that cannot be made to work.
- **Operational Risk:** includes risks from poor implementation and process problems such as procurement, production, and distribution.
- **Market Risks:** include competition, foreign exchange, commodity markets, and interest rate risk, as well as liquidity and credit risks.
- **Legal Risks:** arise from legal and regulatory obligations, including contract risks and litigation brought against the organization.
- **External Hazards Risks:** Including fire, storms, floods, earthquakes; vandalism, and sabotage.

Some important physical and operational risks with the Akriveia Beacon system highlighted are, the resolution accuracy of the indoor location system, failure to carry ID tag during disasters, system integrity during hazardous environments. These risks are associated with system operation and mitigation strategies are developed to reduce the occurrence and impact of these types of risks. Risks relating to the overall project are considered and analyzed in the tables below. The team at TRIWAVE SYSTEMS will perform in depth analysis of all possible risk of the project and create mitigation strategies to best minimize these risks of the project.

Severity	Risk	Likelihood	Mitigation Strategy
Low	Feature creeping inflates the scope of the project.	Medium	Team members all agree on the scope of the product and new features will be further analysed on feasibility and cost/benefit ratio before adding to project.
Low	Team members misinterpret projects requirements.	Low	Requirement documents details concise and clear requirements of the project to minimize misinterpretation during development.
Low	Insufficient project funding	Medium	A self-funded budget has been established and if needed each member can provide additional funding for the project.

Table 1: Project Risk Assessment Table - Part 1

Severity	Risk	Likelihood	Mitigation Strategy
Moderate	Targeted end users have difficulties interacting the system user interface.	Medium	The project will include two phases of usability testing to ensure UI interaction is intuitive. The first with team members as the evaluators and the second with external evaluators.
Moderate	Team member unavailable to perform duties due to illness or unforeseen circumstances.	Medium	Team members are familiar with the core architecture of the system, and with difference domain of expertise all member can be covered by each other, in case of illness or unforeseen circumstances.
Moderate	Miscalculate Project time line, failure to meet project deadlines	Low	Proper project planning strategies such as grant charts and project management techniques will mitigate delays and other unforeseen circumstances.
Moderate	Target audience may not find final product as initiative or easy to use.	Low	Constant communication and feedback between team members and stakeholders can mitigate this risk.
Moderate	System cost may be too expensive for consumers to consider to purchase.	High	As this technology is still in its infancy cost is a major concern, in the future with more refined technology can lower cost along with government incentive for more potential consumers.
Significant	Delay of project due to delay in component purchasing, manufacturing, and shipping.	Medium	Plan purchase dates as early as possible, research multiple vendors and backup component sources.
Significant	Stakeholders incoherent with project definition and scope.	Low	The team will provide clear and coherent communication and project description with shareholders to avoid misinterpreted ideas.
Significant	Targeted location resolution accuracy of 50 cm cannot be achieved.	Low	Create alternative solution to best fit the scope of the project without compromising the integrity of the core system. Such as lowering resolution to 5m zone instead.
Significant	Beacon is destroyed or is offline due to external hazards during emergency disaster after system deployment.	High	The system needs minimal three beacons to operate, in ideals situation there are multiple redundant backup beacons to keep system operational during disasters.
Significant	Location of ID tags generate inaccurate data and increase search and rescue time	Low	The system will be calibrated for each environment and system test drills can be performed to ensure that the system can produce accurate and reliable data.

Table 2: Project Risk Assessment Table - Part 2

2.4 Benefits

The Akriveia Beacon was envisioned as a system to aid first responders in search and rescue operation during small scale disaster situations. As an indoor location tracking system designed for emergency search and rescue operations, the Akriveia Beacon is the first of its kind. The core feature is the near real time tracking of ID tags upto a distance resolution of 50 cm, which is substantial since no system exists with a similar purpose and application. One major benefit of the system is to reduce search and rescue operation time. In dangerous environments during an emergency disaster first responders are exposed to various hazards which creates considerable amount of risk to their lives. To minimize the first responders' and the trapped victims' exposure to these environments is critical. By providing near real time location of trapped victiums the search time is significantly reduced allowing for quicker rescue procedures to be carried out.

Another advantage of the Akriveia Beacon system for the end users is that it provides a simple and intuitive graphical user interface. A clear and intuitive Graphical User Interface (GUI) allows for the first responders to quickly understand and interpolate location coordinates of trapped victims and relay this important information directly to the first line of fire fighters heading into the targeted building. Clarity minimized potential mistakes and error which is pivotal in search and rescue operations.

The Akriveia Beacon system could also generate substantial economic benefits if it were to become a successful product. Successful sales of this product would generate profit which allows for the growth of TRIWAVE SYSTEMS. As well as the build up a brand and company reputation in the industry to further create a multitude of business opportunities. This growth will allow the Akriveia Beacon system to be further refined and improved upon to become an even more robust and reliable system which would revolutionize emergency search and rescue operations.

The final product version of Akriveia Beacon can be further be improved upon to include a vast range of potentials. One major implementation for the system considered was a central cloud management system. Since each beacon has the capability to access any WiFi network, a central cloud server could utilize this feature to create a management system for each individual building installed with the Akriveia Beacon system. A central management system allows for upwards scalability and improved process for system access and maintenance.

3 Current Market & Competitions

3.1 Markets

Currently there are two major markets available for Global Indoor Location (GIL) and Search and Rescue (SAR) equipment. The Global Indoor Location market is worth $ 3.43 billion in 2015 and is projected to reach $ 29.4 billion in 2022 [10]. This advent comes from the increasing amount of smartphone users and ineffective Global Position Systems (GPS) for indoor use. On the other hand, SAR market worth is projected to rise from $ 113.62 billion in 2017 to $ 125.66 billion by 2022 [11]. Mainly the increased focus on citizen safety and rising terroism/insurgency threats supports the upward trend. Suprisingly, UWB is only utilized for GIL market for commercial use in warehousing, breweries, factories and other various applications. However, none uses UWB for GIL in emergency situations as SAR equipment. Therefore, Triwave Systems uniquely positions itself between two multibillion dollar markets, GIL and SAR, and allowing freedom to compete in both.

There are multiple Global Indoor Location (GIL) systems available on the market. Each GIL system relies on their own specific technology and has their own benefits and cons. Based on the journal *Localization and Positioning Systems for Emergency Respondiers: A Survey*[12], there are five categories or attributes on which each GIL are evaluated: Accuracy, Information Accessibility, System Adaptability, System Architecture, System Autonomy and Cost. Of the numerous technologies stated in the journal, only UWB provides the sufficient accuracy and reliability needed for indoor tracking for individuals during emergencies. In fact, UWB if optimized properly can provide the necessary <1m accuracy compared to other technologies. UWB operates on the frequency range from 3.5 to 6.5Ghz band which enables higher accuracy, less interference and multipath propagation effect. Bluetooth and Wifi utilize 2.4Ghz which severely reduces its accuracy due to multi-path propagation effect and interference. Although 2.4Ghz frequency GIL sysytems are inexpensive and readily available, the inconsistent nature of RSSI causes Wifi and Bluetooth GIL systems to be inaccurate [13]. UWB although more costly, can provide the necessary location tracking that our emergency tracking system requires. Thus, UWB technology is the most appropriate for our specific scenarios and use cases.

3.2 Competition

There are a number of competitors in the market that uses the same UWB technology for indoor localization as Triwave Systems. However, the application of their products is mainly associated with tracking equipments and items in warehouse or production facilities, which differs from the scope of search and rescue and does not compete directly with our product. The various companies, infsoft or Pozyx, use UWB for tracking individuals in warehousing. Tracking individuals or items in non-emergency situations do not necessitate the need for high precision localization. As well, use cases where power is out are not considered in the product specifications as vital. UWB applications in non life-threatening situations do not demand such strict regulation or procedures compared to SAR equipment. Triwave Systems' Akriveia also has backup battery power for the beacons in case of emergencies. Since the ID tags are mainly in deep sleep waiting for user input and the beacons emergency broadcast, these ID tags can last several years in deep sleep considering optimal conditions [14]. Another defining feature for Akriveia systems is the integrability of the ID tag with the access card. There will be no need for employees to carry two separate cards but rather one card with both functions.

3.2.1 infsoft

infsoft is a competitor that provides indoor tracking solution mainly to industrial environments using UWB sensors. Similar to Triwave Systems, their tracking system consists of two components: locator tags and locator nodes, for which the locator tags can be attached to people or objects and the locator nodes are installed at fixed locations in an infrastructure. Some suggested uses cases for their UWB locating systems are forklift localization, route analysis, asset tracking and tugger train management, which are mainly in warehouse or production facilties [15]. In applications where locator tags are attached to immobile objects such as asset tracking, such a system would be beneficial as it may prevent incorrect inventories. However, in applications where the locator tags are attached to people such as search and rescue, privacy becomes an issue as their navigation within the coverage area of the locator nodes are exposed in real time. Triwave Systems ensures that user privacy is preserved in all non emergency situations by preventing ID tags to broadcast signals which forbids data reception from our beacons. This solution also decreases power consumption of ID tags significantly, hence lengthening their battery life as well.

3.2.2 Pozyx

Pozyx is another company that provides tracking solutions using UWB technology for production and other industries. With the same system components as of infsoft, the company categorizes its products in two families: Creator and Enterprise. The Creator kit pricing at €1050 consists of 4 tags and 5 anchors is aimed for hobbyist prototyping purposes, whereas the Enterprise kit pricing at €3900 consists of 3 tags and 6 anchors is used in large industrial environments [16]. In terms of accessibility, both product families may not be ideal for their dedicated comsumers due to their high price points. Despite difference in use case, Triwave System integrates components that are less costly to build ID tags and beacons in order to maintain a widely accessible yet cost effective system.

3.2.3 Articles/Journals

Instead of tags and anchors, the wireless sensor invented by the King Abdullah University of Science and Technology is a handheld portable device engineered to detect human body movements such as respiratory chest movements with UWB technology. It is low cost solution with high level of accuracy and the ability to penetrate obstacles due to benefits of UWB technology, which is seemingly ideal for search and rescue [17]. However, problems arise due to the handheld nature of the device in search and rescue. Firstly, the chance of locating victims is highly dependent on the coverage area and direction of the search conducted by the device user. This human dependency may pose limitations to its effectiveness on search and rescue since it is difficult to have full coverage on a disaster site. Lastly, having an extra device to carry can also be an extra burden to first responders who carries gears and equipment during a search operation. Triwave Systems solves these problems by having UWB sensors attached to potential victims instead of first responders. Search coverage is also handled by the distribution of our beacons and our data processing unit allows first responders to locate victims more effectively without carrying a device into dangerous environments.

One article *Indoor localization for evacuation management in emergency scenarios* discusses about using a WiFi system that computes indoor localization to the person's phones [18]. The sensors that detect smoke would send an alarm to the web server which would in turn send alerts to Rescuer apps and Worker apps. The phone app would guide the person to exits or provide emergency assistance. However, the authors exaggerate the effectiveness and accuracy of RSSI. Thus, the article only provides the concept of an Emergency Indoor Localization system without physically implementing it.

4 Budget & Funding

4.1 Budget Estimation

For the Alpha phase of the project, the team plans to test a few transceivers from different manufacturers in order to find the most suitable transceivers for the final prototype. For the microcontroller unit, the ESP32 development board will be used to help test these transceivers with the system. In the following tables, expense that has already been put into the project, and the estimated costs for the remainder of the project are outlined. The expenses are divided into two tables, one containing the expenses already incurred up to the time of this writing, and the other contains a forecast of the expected costs to come.

Item	**Purpose**	**Cost [CAD]**	**Project Phase**
12 of: nrf24l01 2.4GHz RF Transceiver modules	Initial feasibility testing	$17.99	PoC
5 of: ESP32 development boards	PoC and prototype testing and development	$82.15	PoC, Prototype, Final
1 of: Raspberry Pi 3 B+ starter kit	Will act as the demo central data processing unit for prototype and final product	$88.47	Prototype, Final
5 of: Decawave DWM1000 UWB modules	RF transceiver for Prototype and final product	$230.67	Prototype, Final
12 of: DWM1000 PCB breakout boards	Allow for DWM1000 modules to be used with ESP32 in prototype and final product	$18.29	Prototype, Final
Raspberry Pi 3 B+	Will act as the central data processing unit for prototype and final product	$88.47	Prototype, Final
SMD components and solder paste	Assembling the DWM1000 boards	$63.45	Prototype, Final
Arduino boards and components	Testing and development for Data processing unit and serial communication	$107.87	PoC

Table 3: Expenses to Date

Item	**Purpose**	**Cost [CAD]**	**Project Phase**
3D printing	Casing for beacons and ID tags	$50.00	Final
Batteries	Power supplies for system components	$30.00	Prototype, Final
Circuit components	Beacon and ID tag components	$20.00	Final
PCB printing	Beacon and ID tag components	$20.00	Final

Table 4: Forecast of Future Expenses

4.2 Product Pricing

The Akriveia Beacon as a Final manufactured product will offer its customers 10 ID Tags with minimal 3 Beacons which additional beacons and ID tags available for purchase at unit and bulk price. The final system will have an estimated system component cost of around $575. Along with an estimated labor and overhead cost the required final product sale price is estimated to be around $930 with a 20% return on sales (not including taxes).

System Component	**Part**	**Cost [CAD]**
ID TAG	DWM1000 Module	$30.00
	Casing	$2.00
	Integrated ESP32 PCB	$2.00
	2200 mAH Lithium Battery	$5.00
	PCB Components	$2.00
	Total:	$44.00
Beacon	DWM1000 Module	$30.00
	Casing	$3.00
	Integrated ESP32 PCB	$2.00
	2200 mAH Lithium Battery	$5.00
	PCB Components	$2.00
	Total:	$45.00
Software	Deployment Cost	$50.00

Table 5: Final Product Pricing Estimation

Cost of materials	
+ 10 × ID Tag	$440.00
+ 3 × Beacon	$135.00
+ Cost of labor	$100.00
+ Overhead	$100.00
= Total cost	$775.00
+ Desired profit (20% on sales)	$155.00
= Required sale price	$930.00

4.3 Prospective Funding Sources

4.3.1 Engineering Science Student Endowment Fund

We hope to obtain funding from the SFU Engineering Science Student Society (ESSS) by means of the endowment fund set up by the society (ESSEF). We know that they have been very generous with Capstone groups in the past, so as soon as we are able to, we will be applying for funding from the ESSEF. We acknowledge that some parts purchased with the funding from this source may have to be donated to the ESSS for their parts library.

4.3.2 Wighton Development Fund

The Wighton Development Fund is in place to support SFU student-led projects, awarded by Dr. Andrew Rawicz [19], and a comitee consisting of other facuty or staff. We hope to obtain funding that will cover the remainder of the expenses endured during this project. As with the ESSEF, an application will be submitted by this group as soon as possible.

4.3.3 Team Contributions

If the above funding sources are insufficient to cover the costs of this project, each team member will agree to personal contributions up to $50 each to complete funding for the project and cover any remaining expenses.

5 Project Planning

The development of the Akriveia Beacon system will go through three different phases of development: the Proof of Concept phase, the Prototype phase, and the Final Product phase. The development of these three phases will span over a time period of eight months (two semesters), starting from May 2019 and ending in December 2019 as shown in the project milestone chart in figure 6.

The Proof of Concept phase will be delivered at the end of the first four months (first semester) in August 2019. The Prototype phase will be complete in October 2019 (in the middle of the second semester). Lastyly, the Final Product phase will be delivered at the end of the eight months (two semesters) in December 2019.

The 405W project development timeline can be viewed in the Gantt chart presented in figure 7. This Gantt chart details the tasks and milestones associated with the proof-of-concept development phase of the Akriveia Beacon system. This Gantt chart does not include tasks and milestones in 440 as the timeline for 440 is unclear at the writing of this document. Furthermore, the two tasks, Prototype UWB Testing and Prototype UWB System Integration listed under number 21 and 22 respectively, will continue into 440 as UWB development will continue past the PoC development phase.

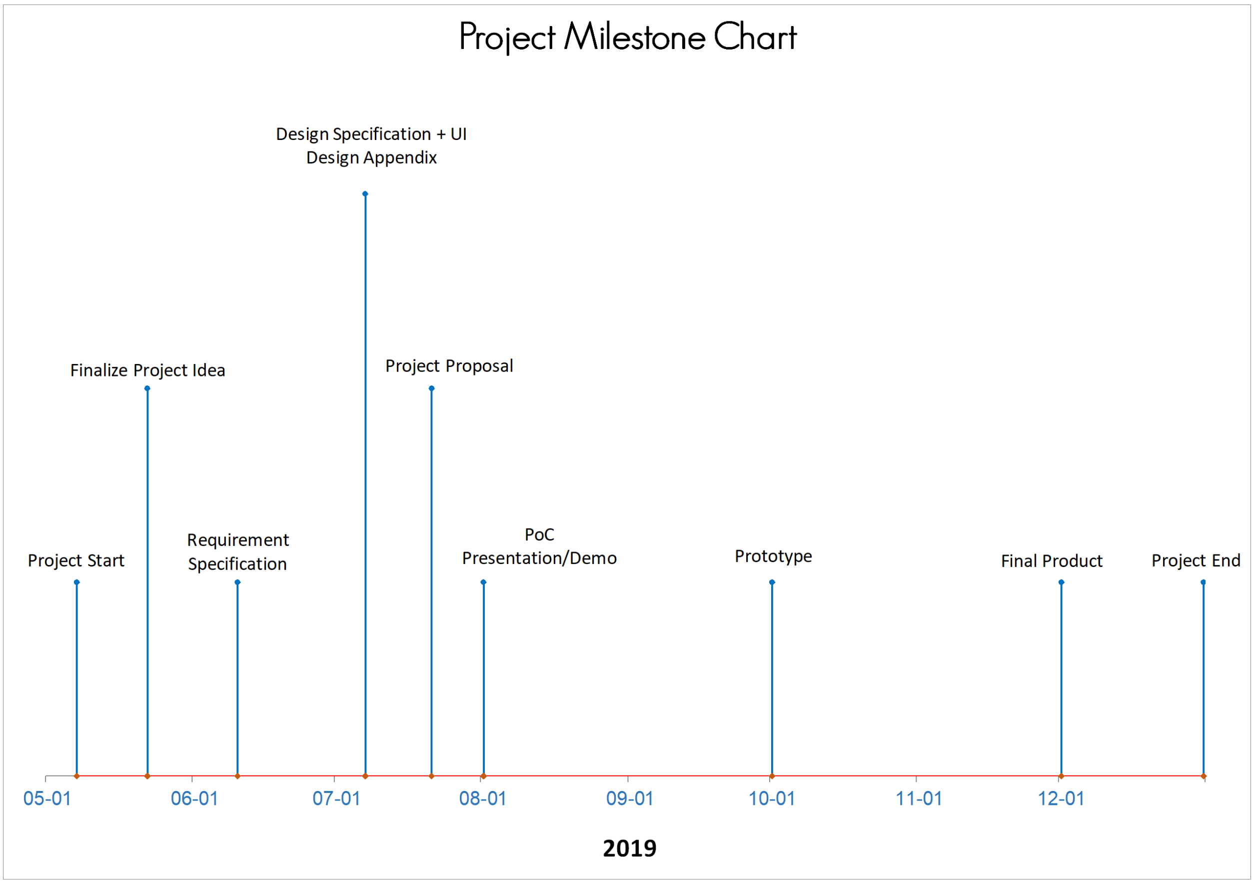

Figure 6: Project Milestone Chart

ID	Task Name	Duration	Start	Finish
0	**Project**	**87 days**	**05-07**	**08-01**
1	**Project Idea**	**15 days**	**05-07**	**05-22**
2	Project Brainstorming	10 days	05-07	05-16
3	Expert Interviews	4 days	05-17	05-20
4	Finalize Project Idea	0 days	05-22	05-22
5	**Documentation/Presentation**	**72 days**	**05-22**	**08-01**
6	Requirement Specification	18 days	05-22	06-08
7	Requrement Specification Due	0 days	06-09	06-09
8	Design Specification	27 days	06-10	07-06
9	UI Design Appendix	27 days	06-10	07-06
10	Design Specification + UI Design Appendix Due	0 days	07-07	07-07
11	Project Proposal	13 days	07-08	07-20
12	Project Proposal Due	0 days	07-21	07-21
13	Presentation/Demo Prep	10 days	07-22	07-31
14	Presentation/Demo	0 days	08-01	08-01
15	**Hardware Development**	**72 days**	**05-22**	**08-01**
16	Feasibility Research	8 days	05-22	05-29
17	Order Parts	6 days	05-24	05-29
18	PoC BLE RSSI Testing	20 days	05-30	06-18
19	PoC System Integration	35 days	06-18	07-22
20	Order Parts	22 days	06-26	07-17
21	Prototype UWB Testing	9 days	07-24	08-01
22	Prototype UWB System Integration	2 days	07-31	08-01
23	**Software Development**	**72 days**	**05-22**	**08-01**
24	Feasibility Research	15 days	05-22	06-05
25	Software Design	41 days	05-30	07-09
26	System Integration	35 days?	06-18	07-22
27	Testing	11 days	07-22	08-01
28	**Testing**	**11 days**	**07-22**	**08-01**
29	System Testing	10 days?	07-22	07-31
30	Usability Testing	10 days	07-22	07-31

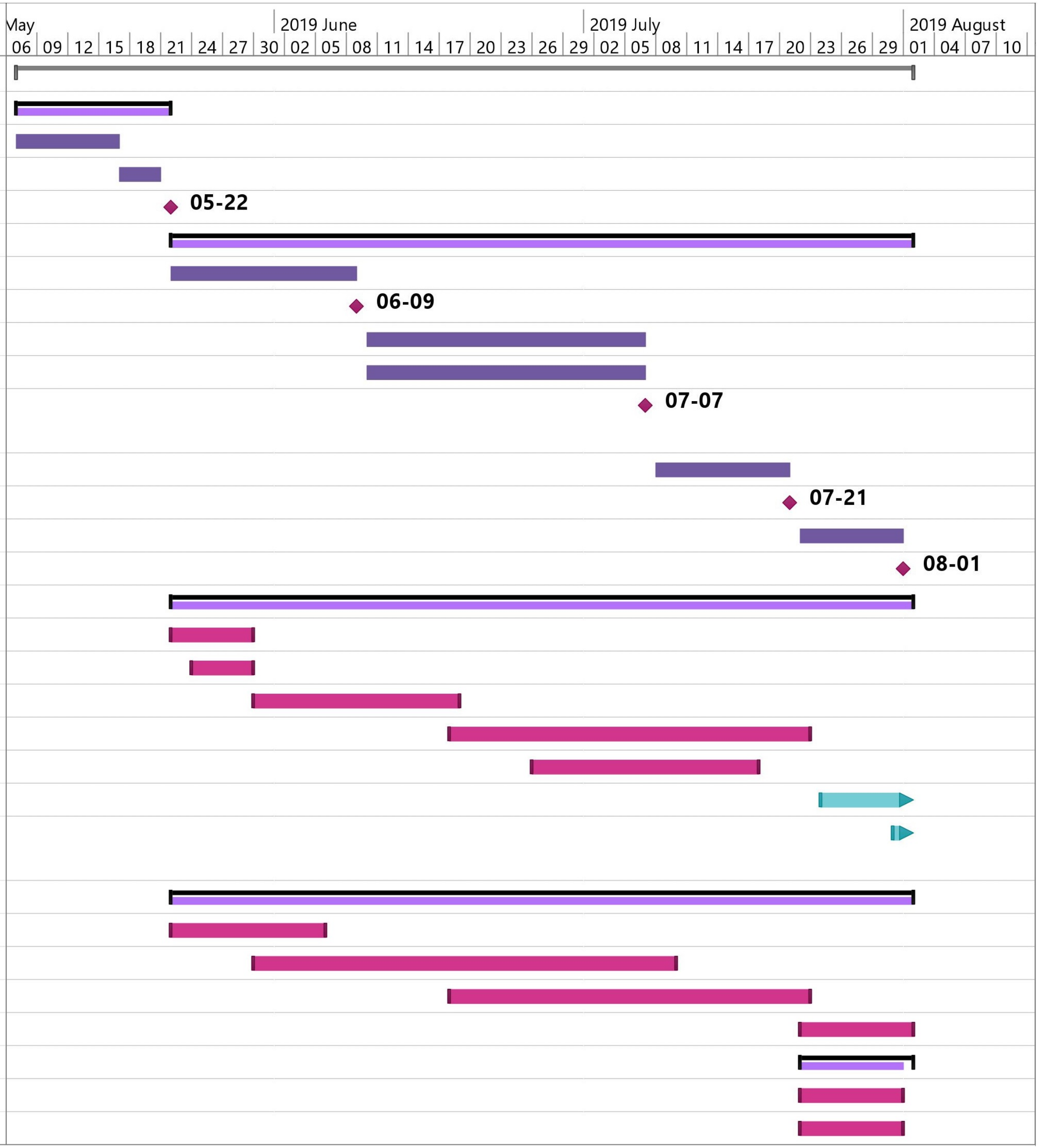

Figure 7: Project Gantt Chart

6 Company Details

Name: Jerry Liu

Title: Chief Executive Officer (CEO)

Background: Jerry is a 6th year Computer Engineering student at Simon Fraser University where he has gained fundamental knowledge in programming, embedded systems, and software development. From his previous experiences, he developed skills and comprehensive knowledge about hardware, software, and system level design. Jerry has co-op experience in the telecommunication industry from working at Sierra Wireless. At Sierra Wireless, he worked on industry leading, dual-LTE-Advanced vehicle networking platforms designed for applications in extremely harsh indoor, vehicle or exposed outdoor locations. He has also worked for two semesters as a co-op student under a professional research laboratory the Laboratory of Alternative Energy Conversion (LAEC). At LAEC he provided development for custom data analysis software in both MATLAB and python as well as built and maintained various experimental test beds for sustainable energy and heat transfer applications such as adsorption cooling systems, capillary assisted low pressure evaporator, and graphite heat sinks.

Name Jeffery Yeung

Title: Chief Communications Officer (CCO)

Background: Jeffery is a 6th year engineering science student at SFU pursuing a degree in Systems Engineering. His previous experience includes working at Mix Technology Inc. in Hong Kong and Integral Group in the Vancouver office. He has gained valuable experience in PLC software design and gained valuable insight into Hong Kong's diverse and booming construction industry. His time at Integral Group further cemented his understanding of building verification and the importance of proper building commissioning. He hopes to apply his acquired skills and experience in the construction industry towards machine learning for building HVAC. His goal is to reduce building HVAC energy consumption and advance sustainability or green practices in building design.

Name: Keith Leung

Title: Chief Technology Officer (CTO)

Background: Keith is a 6th year engineering science student pursuing a degree in computer engineering at Simon Fraser University. Through his academics, he has gained extensive software development experience with C and C++, as well as basic data mining knowledge with R. His past co-op experience at TELUS as a Wireless Access Engineer has exposed him to the telecommunication industry. At TELUS for three semesters, he performed extensive research and development on various wireless technology, including LTE, 3G, Wi-Fi and small cell indoor solution in lab environments. Keith specializes on an LTE-Advanced feature called Carrier Aggregation (CA) to establish throughput breakthroughs for commercial subscribers. As the CTO of Triwave Systems, he aims to be the solution architect to the wireless aspects involved with the project.

Name: Scott Checko

Title: Chief Operating Officer (COO)

Background: Scott is a 5th year Computer Engineering student at Simon Fraser Universtiy with a focus on development of webservers and embedded programming. In his previous experience at SpeedLine he worked on a Cloud based MicroServer Platform for a new Online Ordering framework using Amazon Web Services that would serve restaurants across Northern America. He also worked at Avigilon, maintaining and adding features for a physical Access Control application to manage Mercury and HID controllers and other hardware to prevent unauthorized user access into buildings. At both SpeedLine and Avigilon, Scott learned to hone skills such as Agile workflow, collaberation software, teamwork, leadership, quality assurance, and a plethora of different programming languages ranging from C++ to Javascript, including the Yocto Project to build and maintain a custom Linux based operating system.

Name: Ryne Waterson

Title: Chief Information Officer (CIO)

Background: Ryne is a 6th year electronics engineering student at Simon Fraser University. His time in the program has given him skills in designing and analyzing electrical circuits, programming, and microelectronic systems. A minor in physics has allowed him to gain insight into the fundamental mechanics of natural systems. Ryne has experience working in research for Dr. Marinko Sarunic, doing all three semesters of co-op in his lab. During his time here, Ryne worked with cutting edge medical imaging systems, using Optical Coherence Tomography (OCT) to image mouse retina . At the end of his last term of co-op, Ryne attended the annual Association for Research in Vision and Ophthalmology (ARVO) research conference, where he presented his research alongside other research scientists from all over the world.

7 Conclusion

As urban centers around the world experience rapid growth and changes so does the risk of being potentially trapped within buildings during disasters. The time period right after a disaster strikes is the most critical time for saving victims lives. In current practices, first responders have limited time to evaluate the situations when they arrive on the scene of disaster and must take crucial actions accordingly. Searching the incident building for possible victims is one of the major tasks undertaken by first responders after an incident occurs. The lack of timely information could be the difference between life and death in such situations.

As such, a reliable and accurate indoor location rescue system is needed to aid first responders in locating trapped personnel. The Akriveia Beacon is a system of anchor beacons and ID tags controlled by ESP32 micro-controllers and communicating via Decowave DWM1000 UWB modules, along with trilateration algorithm to accurately obtain near real time location of trapped personnel within buildings during the event of a disaster. The location data is then reported to a portable data processing unit via a closed WiFi network, which can be interacted with directly by emergency first responders and operators to provide accurate and reliable information for the search and rescue effort.

This project proposal document provides a brief overview of the system architecture, a perspective on current markets and potential competitions, discuss project planning, available budget, and funding, as well as an introduction to the development team at TRIWAVE SYSTEMS. This proposal document will cover the mentioned section over the development of the Akriveia Beacon product through three different phases including: the proof-of-concept (completed August 2019), prototype, and final product (completed December 2019).

Although this project might be challenging, the team at TRIWAVE SYSTEMS is confident that through hard work and careful planning the Akriveia Beacon system will deliver all of its promised features. Even with a lack of external funding, the team is assured that the project will still meet its promised milestones and provide top end quality through a self-funded budget. As a product that could potentially affect the outcome of disaster relief operations, the Akriveia Beacon is designed with the utmost care. As aforementioned, TRIWAVE SYSTEMS is dedicated to creating a reliable and robust indoor location tracking system designed to improve disaster search and rescue operations with human safety as the pivotal focus.

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