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July 25, 2021

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

RE: ENSC 405W Project Proposal for OpenSpot

Dear Dr. Craig Scratchley,

Attached in this document you will find the Project Proposal for our smart parking system OpenSpot. We collectively designed this system with the end goal of alleviating the stress involved in finding open parking spots within busy lots. Using mounted cameras and our computer vision application, we allow users to view available parking spots through a website and the ability to view the density of occupied stalls through an LED light indicator.

This document will contain details regarding our funding proposal along with an overview of OpenSpot itself. It will include an executive summary, introduction, project overview which includes a background and scope, project justifications, finances, project planning, and company details. In addition, it will detail areas such as the current market and competition for OpenSpot along with an analysis of the risks and benefits associated with our smart parking system.

Our team is composed of students from both Computer Engineering and Systems Engineering disciplines: Justin Naorbe, Curtis Lui, Gurmesh Shergill, Soroush Saheb-Pour-Lighvan, and Darius Nadem. With the variety of our skill sets along with the determination and passion to create a system that saves drivers both time and potential frustration.

We would like to thank you in advance for taking the time to read the attached project proposal document. If you have any further questions or comments, please feel free to reach out to our Chief Executive Officer Justin Naorbe at jnaorbe@sfu.ca.

Sincerely,

Justin Naorbe
Chief Executive Officer
OpenSpot

Enclosed: Project Proposal for OpenSpot

OpenSpot

ENSC 405W

OpenSpot Funding Proposal

Company 7

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July 25, 2021

Executive Summary

As populations and accessibility to driving have increased, finding parking has become difficult in busy areas such as universities, malls, and stadiums. A smart parking system allows drivers to save valuable time and prevent unnecessary frustration while seeking a vacant stall. Indicators act as a tool to help guide traffic and inform drivers well before they start their search. With congestion removed and reliance on luck out of the equation, time wasted, and vehicle emissions are decreased for a more pleasant parking and visiting experience.

OpenSpot is developing a smart parking system consisting of computer vision, light indicators, and a website with real-time spot specific statuses. The system is packaged in a discrete hardware module to be mounted on existing light poles which ensures complete coverage and easy installation for a low entry to barrier solution. The LED light indicator informs drivers about the current density of parked cars around the light poles. This gives drivers an understanding of how easy or difficult it may be to find a vacant spot and guide them to take calculated risks in terms of time spent seeking a parking stall.

Security within parking lots is a concern among drivers due to incidents involving vehicle break ins, vandalism, and hit-and-runs. As a solution to this ongoing issue, the module houses a microphone to capture audio recordings which are analyzed to detect the presence of active car alarms. Upon detection, an alert is sent to parking lot owners and security personnel to help them promptly respond to an incident. This will give drivers peace of mind knowing that their vehicle will be monitored throughout the duration of their stay.

Along with the light indicators and website, OpenSpot's smart parking system will allow users to subscribe to text notifications to receive alerts about the status of the parking lots in which they are interested. The added information before arriving at the parking lot will greatly reduce frustrations and allow drives to adjust their search strategy accordingly.

The global market for smart parking systems was $4.4 billion in 2020 with an expected compound annual growth rate of 21% over the next 7 years [1]. The current market size for the parking lot industry is around $9.4 billion which indicates that there will not be a lack of opportunity to install our smart parking system [2]. OpenSpot's modules are a cost-effective way to integrate a smart parking solution that can cover multiple parking stalls and the entire system can be installed on existing parking infrastructure. The entry to barrier is low as it saves money from less hardware to maintain and decreased installation costs which will attract and incite potential clients.

Our team is excited to offer OpenSpot as a smart parking system that is cost effective, enhances the presence of security, and saves users valuable time by keeping them actively informed. As a team of five determined and hard-working engineering students with experience in areas such as hardware, software development, and system design, we are excited to offer a system to advance the world of smart parking solutions.

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Glossary

CAGR	Compound Annual Growth Rate
Clients	Corporations or Person(s) who own the parking lot
IoT	Internet Of Things, describes the network of technologies with the purpose of connecting and exchanging data over the internet
IP Rating	Ingress Protection Rating, sometimes referred to as International Protection Rating. Classifies the degrees of protection provided solid objects, dust, accidental contact, and water in electrical enclosures
LED	Light Emitting Diode (a semiconductor diode which glows when a voltage is applied)
PoC	Proof-of-Concept, in reference to the prototype
RGB	Red Green Blue, in reference to the colour spectrum
Users	Everyday drivers who will interact with our smart parking system

1 Introduction

With the ongoing increase in population and rapidly growing concerns with climate change, sustainable options are sought out every day as technology continues to advance. This is especially present in the automotive industry where electrical vehicles have made great strides in replacing gasoline vehicles. In contrast, the parking industry has made little advancements to integrate new infrastructure and improve parking efficiency. Drivers are dependent on luck and their limited field of vision of the parking lot to find vacant spaces. Our smart parking system provides user with real-time parking lot information to make well-informed and in advance parking decisions. We plan to bridge the gap between old parking methods and new advancements in technology, to reduce the environmental impact from idle cars and ease the frustrations that arise from day-to-day parking [3] [4].

Many smart parking systems available today utilize a sensor for each parking spot which results in a high barrier to entry where the hardware and installation costs increases linearly. At OpenSpot, we are developing a cost-effective solution where a single module can cover 10-20 parking spots, utilizing a single camera and our computer vision algorithm. These modules are designed to be mounted on pre-existing light poles to reduce installation costs and to take advantage of the existing infrastructure. Parking density information, around light poles, is relayed through the LED light indicator on the module. Spot specific information can be viewed through a user-friendly website. In addition to parking assistance, our system offers a security feature to detect active car alarms to alert the security personnel for a prompt response to potential incidents.

By creating cost effective modules and a seamless user experience, we will lower the barrier to entry and become an attractive option for parking lot owners to consider. With society's continuous effort to improve the quality of daily life, we plan to ramp up the parking industry to a higher standard to tackle crime and environmental impact.

The proposal outlines all the factors and considerations that we have made in designing our system. It begins with the high-level overview of our system and the scope of our proof-of-concept (PoC) prototype. The risks and benefits of our project will be discussed in detail, as well as an overview of the current market and competition for smart parking solutions. The financial section details the cost and sources of funding related to the development of the PoC prototype. The planning section contains a roadmap, in the form of a Gantt chart, for the first period of development is presented. Lastly, details regarding our team members experience and roles within OpenSpot are outlined.

2 Project Overview

2.1 Background

Our solution consists of three main systems: hardware module, backend server, and a website. The modules are the necessary hardware to collect and send data to our backend server. They also act as the key interface for drivers at the parking lot, as it houses the indicator light. Figure 2.1 and Figure 2.2 are mock-up models of what our module would look like while mounted on a light pole.

Figure 2.1: Mock-up of Module Mounted on Light Pole

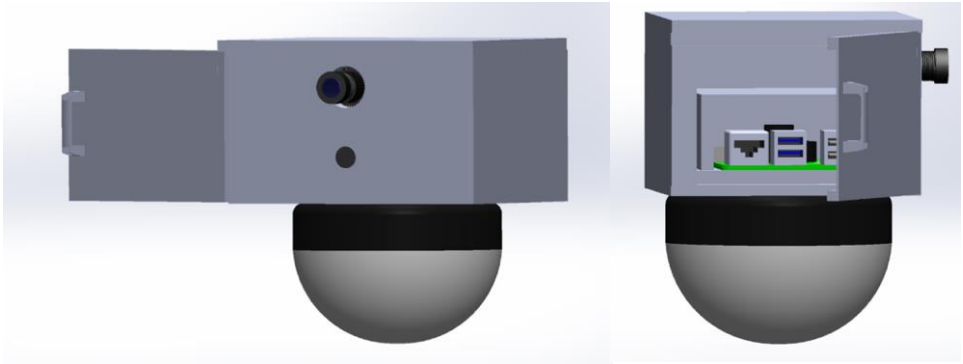


Figure 2.2: Close up of Mock-up of the Module

The backend server acts as the brains of our solution. It responds to requests from the module and performs all the necessary computation that is involved in determining whether parking spots are vacant or not. In addition, if an active car alarm is present in an audio recording a notification is sent to the client. It also hosts the website and ensures that it is always displaying real time parking information to users. The website acts as the primary user-interface. It displays the spot specific occupancy status in an intuitive manner on a map of the parking lot. Through the website, users can sign up for text notifications for their parking lots of interest and clients can view the analytics relating to their parking lot. A mock-up of the website interface is shown in Figure 2.3. The complete system and communication channels can be seen in Figure 2.4.

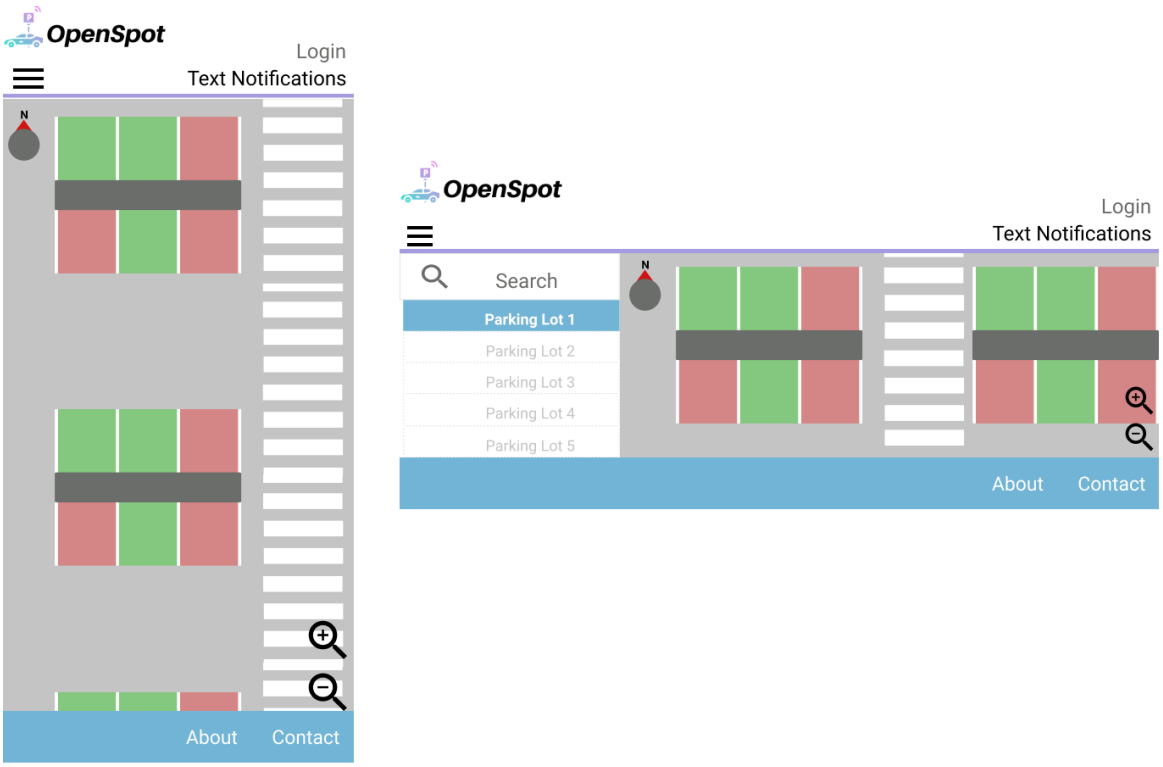


Figure 2.3: Mobile Landing Page of Website - Portrait (Left) and Landscape (Right)

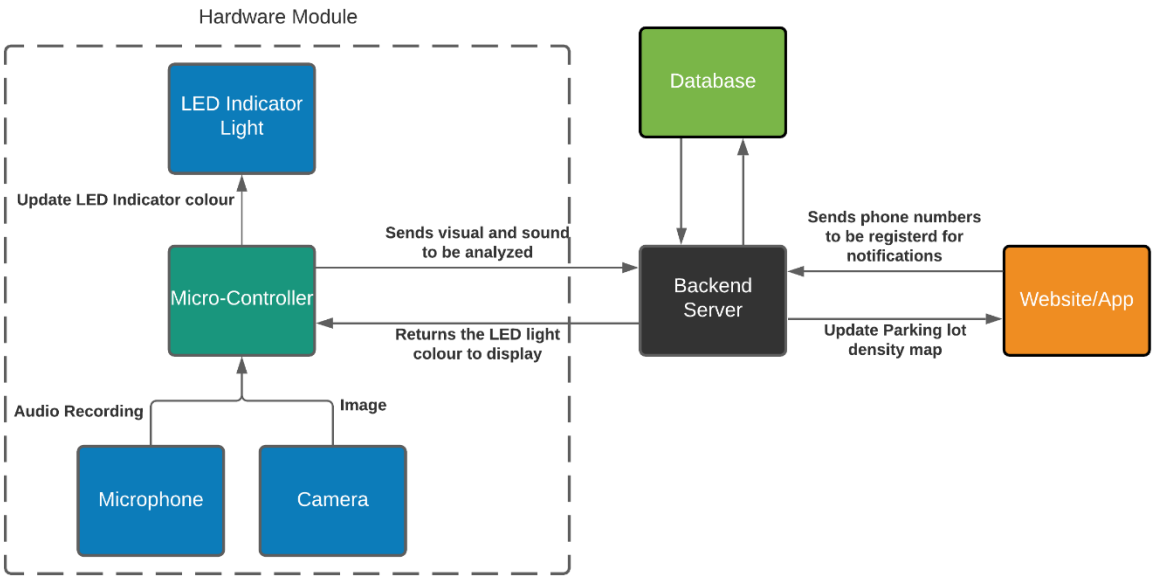


Figure 2.4: OpenSpot's System Overview

2.2 Project Scope

The PoC prototype, to be presented in mid-August, will be able to collect and process real time data. It will determine the vacancy percentage of a given parking lot and set the indicator light to the correct colour. The success of the prototype will be measured based on the following features and functions that are listed below:

1. Hardware module captures high quality images
2. Hardware module sends data to the backend server
3. The backend server receives data for processing
4. The computer vision application accurately and efficiently determines the status of each parking spot in the image
5. Spot specific data is stored on the database regarding the status
6. Depending on the density and margin calculated from the compute vision application, the backend server will response to module to set the indicator light colour
7. Hardware module receives a response from the server and sets the indicator light colour as specified

To ensure success when developing the complete solution for the engineering prototype, we will meticulously follow the schedule specified in Section 5 Project Planning. This will enable a solid foundation to add features and create a prototype that is closer to what is expected during production. The features that remain to be implemented while developing the engineering prototype are as follows:

1. Hardware module captures audio recordings and send it to the backend server for analysis
2. Audio recognition application on the backend server analyzes recordings and determines if car alarms are present
3. Website displays spot specific status in a clear and intuitive manner
4. Robust text notification system that users can sign up for and get updates regarding the parking status of parking lots

Throughout the different prototyping periods, we will follow the test plans that we have created to verify the functionality of each subsystem and overall system.

3 Project Justifications

3.1 Risks

Currently, OpenSpot does not predict any safety or health hazards from the smart parking system. There is some inherent risk during installation as the mounting points are high up and require electrical work on high voltages to power the module. However, a trained professional will be hired to carry out any installation tasks required. The primary risks that will be discussed pertain to the possible failures of the system.

3.1.1 Hardware

The hardware modules are to be mounted at a height above 3.5 meters. At this height there is a risk of the module falling and causing injury or property damage. We have taken the necessary precautions to identify follow engineering standards for mounting devices, choosing the correct materials, and methods to ensure this risk is mitigated.

The modules are also susceptible to damage from environmental factors. It is planned for the production prototype to have a complete weatherproof housing to reach an ingress protection (IP) rating of IP65. With this rating, the housing will be dust tight and effective from water projected by a nozzle of 6.3mm against the enclosure from any direction [5].

Since the modules are powered through the electrical grid that the light poles work on, they will only be operational when there is power coming from the grid. Currently, we do not have any plans to add a backup battery in the case of a power outage. The potential benefits of keeping drivers informed during a power outage would not outweigh the extra cost and considerations associated with keeping the system running during this unlikely scenario. This is a calculated risk we have deemed necessary for us to take to keep our costs low and increase the likelihood to be adopted by potential clients.

3.1.2 Software

In terms of software risks, there may be instances of unexpected failures or shutdown from any of the components. The software aspect of our system considers the backend server which will host our computer vision and audio recognition application, and website. Each component has associated risks and we have designed our system with this consideration in mind.

The computer vision application may have difficulties detecting parked cars within lots during harsh weather conditions. This may include weather conditions such as thunderstorms, snow, and hurricanes which will cause stress to our system. In consideration of this, our team has decided to make use of median filtering on the images sent to be analyzed by our computer vision application. This will allow for the removal of unnecessary noise to provide a clearer image [6]. Although this may not provide the best possible image in terms of quality, it will allow for the computer vision application to function under more optimal conditions. Another area to consider would be any unexpected shutdowns or failures of either the website, database, computer vision or audio recognition application, and the backend server itself. We have recognized that for our system to function in an optimal manner, each component must be online and available. If a failure or shutdown occurs, we have decided to have monitoring tools in place to send an alert to our administrators so that they may investigate this occurrence immediately. By doing so, this will minimize any potential downtime and provide a useful safety measure.

Another area to consider would be the risk in hackers infiltrating our system in any capacity. Since our backend server will be hosted on an Amazon Web Services (AWS) instance, we inherit the provided security and reliability AWS provides. With the help of following appropriate engineering standards and using the security architecture provided by AWS, we will be able to mitigate this risk to some extent.

3.2 Benefit

OpenSpot was created with the main goal in helping drivers efficiently locate vacant parking spots. After researching available system and user surveys, we have designed our system to include multiple necessary features as well as new functionality while keeping our costs low.

3.2.1 Drivers and Users

Our focus for the initial design of the OpenSpot solution was targeted towards universities with uncovered parking. To gauge the desirability of our system, we conducted a survey to determine driver's experiences with finding parking. With over 50 student responses, 28 of them from SFU, 93% of responses indicated that they struggled to find parking at their desired locations. We also asked questions about the aspects of our solution and 96% agree that indicator lights would be helpful and

89% of them would sign up for text notifications. From these responses, we can confidently assume that our solution can be proven helpful in any other location with busy parking lots. For example, on summer days parks and beaches are exceedingly busy and parking is often extremely hard to come across. Users could view the number of parking spots occupied at parks or beaches from our website to determine which one is worth making a trip to. The consensus from drivers is saving time and avoiding the headache of finding parking is desired.

3.2.2 Parking Lot Owners

Clients will be able to obtain significant statistical information about their parking lot. Identifying peak hours will allow for smart business decisions with regards to how much they should charge or when they should host events. Furthermore, with an easier parking experience more drivers will be enticed to park at the respective lot, instead of trying to find parking somewhere else - increasing the business throughput at their compound. In addition, with the security features provided by the module, drivers will feel comfortable leaving their vehicles at their destination. With less traffic, the probability of potential accidents will decrease and results in a smoother flow of vehicles.

When speaking with SFU Parking, they indicated that the current solutions are expensive as they require hefty installation and infrastructure due to having sensors located at each spot. We have taken this feedback into account and made it one of our selling points. Through using modules that are mounted on pre-existing light poles we can cover the entire parking lot without the need for new poles or wires being run underground, resulting in relative low-cost solution.

3.3 Market Analysis

OpenSpot's smart parking solution is primarily designed for businesses or organizations with uncovered outdoor parking lots with pre-existing infrastructure. This includes places such as universities, shopping centres, supermarkets, parks, and beaches. During our research we have reached out SFU Parking to receive any feedback on the feasibility of our solution in their existing parking lots. Through our conversations, we have received feedback and insights into making our solution more functional and marketable. Outdoor parking lots are our primary targeted due to the potential ability to observe a large amount of parking spots with a single module. By doing so, we are making this solution as cost efficient as possible which should make it more attractive to business owners. As a result of adopting a smart parking solution, visitors will have an easier time finding parking. Removing the headache and worry when finding parking will make for a more inviting experience.

3.3.1 Smart Parking System Market

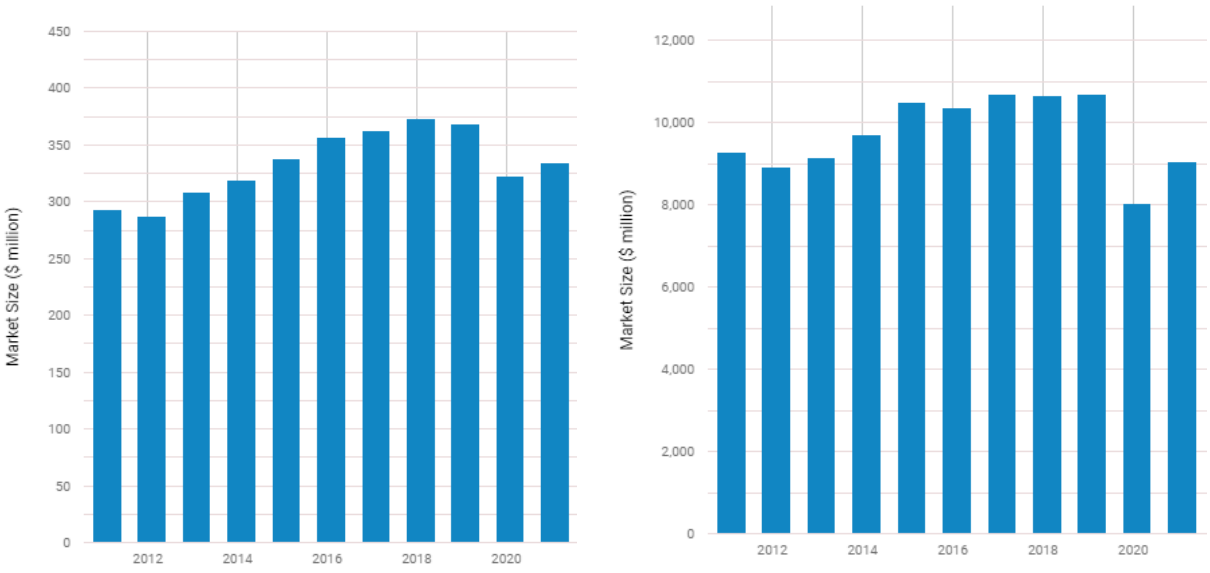
In 2020, the global smart parking market was valued at US$6.59 billion and is projected to reach US$16.74 billion by 2028, growing at a CAGR of 12.36% from 2021 to 2028 [7].

Figure 3.1 The Expected CAGR in the Global Smart Parking Market [7]

Due to a combination of an increase of Internet of Things (IoT) technology and growing concerns of vehicle congestion in a growing population, the smart parking market has seen an incredible growth. There may still be some resistance to this technology since implementation of IoT is comes at an excessive cost due to the high configuration complexities [7]. However, with the new wave of smart cars developing, continuous advancements in technology are expected to expand the growth of this market in the future. Smart parking systems also tackle issues such as air and noise pollution due to congestion and overcrowding. Government globally have encouraged adoption of systems that involve these issues and in turn, create policies contributing significantly to market growth[1]. There are many sub-industries that contribute to the smart parking market such as hardware, software, and service industries such as security. The parking guidance system segment has dominated in 2020 and accounts for the largest revenue share of over 75% [1]. From this, we can see that our smart parking solution has a positive outlook within the global market.

3.3.2 North American Parking Lot Market

The current market size for the parking lot industry in Canada and United States (US) is approximately US$9.4 billion and is projected to grow by 1.1% equating to an increase of US$102.6 million in 2021 [2] [9]. The market size for each respective country from 2011-2021 is shown in Figure 3.2 below.



Market Size in Canada [9]

Market Size in the US [2]

Figure 3.2 Market Size in Canada (left) and the US (right)

The Canadian market depends on the number of motor vehicle registrations to increase since the more cars that are on the road, the more the demand for parking lots increase [9]. Canada's estimated population has climbed from 35.8 million people in 2016 to 37.8 million in 2019 [10]. From this, we can see the correlation between population and vehicle registrations as the amount of total vehicle registrations has increased from 33.8 million in 2016 to 35.7 million in 2019 [11]. We can only expect that the number of vehicle registrations has continued to rise and the need for parking will increase as well. With the upsurge of drivers, a need for parking, and a 3.6% parking market size growth in 2021, it is conservative to say parking solutions such as OpenSpot's will continue to gain attention.

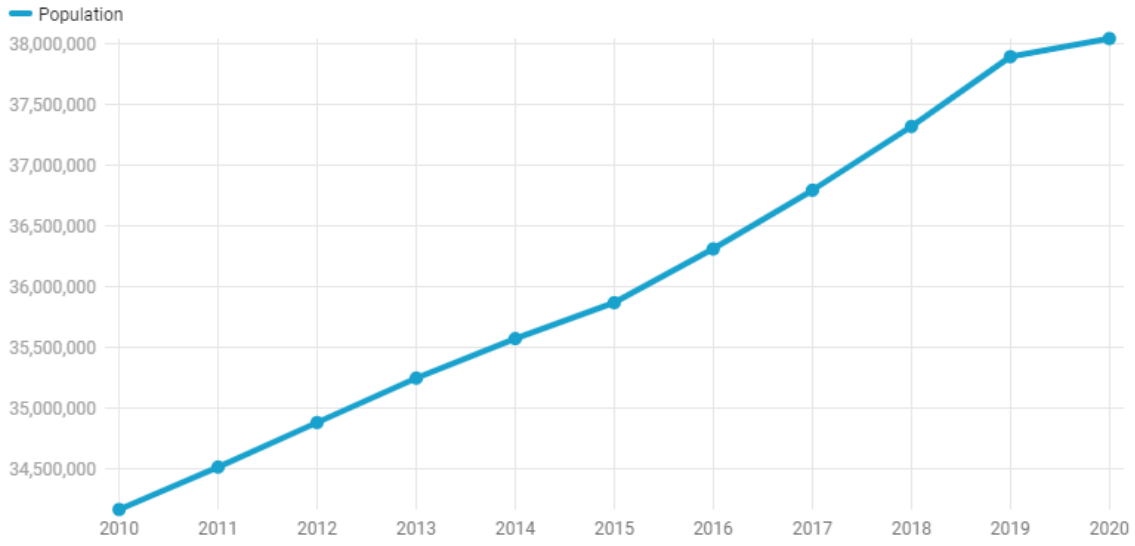


Figure 3.3 Canada's Estimated Population from 2010 to 2020 [12]

The US market depends on employment rates since work commuters' amount to the largest portion of daily drivers [2]. As the unemployment rate has continue to fall from 14.8% since the start of COVID to 5.9% currently [13], there will be more and more cars on the road increasing congestion. Unemployment is expected to continue decreasing which should proportionally affect the demand for parking services.

Figure 3.4 Unemployment Rate in the US from Jan 2020 to July 2021 [13]

The North American smart parking system market was valued at US$1.3 billion in 2018 and is projected to continue to grow from 2019-2025 [14]. Market growth will continue to propel forward as urbanization around the world continues to grow, leading to congestion in cities.

The off-street segment of the smart parking market has captured the largest market share in 2018 [14]. As population increase and unemployment drops, the number of parking garages or lots will continue to increase as well. In the US and Canada, free plots of land are turned into large parking lots where analytical solutions have been implemented to allow users to check availability for booking parking slots [14].

The engineering service segment was valued at US$158.7 million in 2018 and the mobile application parking services segment is also expected to continue to grow. Industries have been focused on creating mobile applications that involve easy booking of parking slots and payment systems for compliance monitoring. Companies prefer to outsource designs and engineering services such as smart parking meters and guidance signage to focus on aspects such as marketing instead [14].

The parking guidance system segment was valued at US$279.1 million in 2018 [14] and can be expected to grow as congestions increases. The focus of this segment is to reduce the time consumption of drivers and to cater to client requirements. The analytical solutions segment is also expected to grow as companies will begin to adopt tools that aid in the information gathering of vehicles, locations, availability, and reservations [14].

With OpenSpot's smart parking solution being mainly targeted towards off-street parking facilities, we can optimistically see it being adopted in many areas by participating in different segments of the smart parking market. For example, by providing a website-based service to motorists we can be included in the mobile application segment. The data obtained by the module can be applied to engage in other segments such as the engineering service segment, guidance system segment, and the analytics solution segment proving that the possibilities are endless with OpenSpot.

3.4 Competition

With any new product or solution, there come certain risks of adoption. We face risks such as not being accessible enough by the general population. This can be remedied by making our solutions interface easy and simple to use. Another potential risk involves not being accepted by our target markets. This may be because they do not think our solution is necessary or clients are not willing to spend the money to adopt it. If we can provide data and show how OpenSpot is beneficial to their company, willingness to adopt may increase. We are also in the age of companies actively attempting to do their part in reducing pollution. We can take advantage of this by providing data to show them that our smart parking solution is not only more convenient for their business, but it is helpful to the environment as well. As technology continues to advance, a more efficient solution may be found that renders ours irrelevant. The OpenSpot team feels that this should not be too much of an issue because the direct solution to this parking problem would be through autonomous vehicles locating available spots and having the ability to park themselves which should not be available as a solution soon. Compared to other pre-existing smart parking solutions, we feel that we have enough key differentiators that separate our solution from others currently available on the market. Our main differentiators are as follows:

1. We do not need a sensor for every spot since a camera can cover multiple parking spots
2. We provide a security aspect to our solution which most companies have not addressed
3. We will provide a reliable and convenient website that is user friendly and contains extensive information
4. We will provide the ability to sign up for features that help the parking experience such as text notifications on certain areas parking availabilities

The idea of smart parking is not a new one and as such, there are many different existing smart parking solutions all around the world. Many of them, however, focus on different areas of parking or are mainly based in Europe, leaving the North American market relatively untapped.

3.4.1 Stanley Robotics

Stanley Robotics, based in France, takes an unorthodox approach in the smart parking solution space. They are the world's first autonomous outdoor car storage solution. Their solution consists of car movers attached to an autonomous robot and have it act as a valet. They have mainly focused on the airport market and automotive industry. For airport application, the user would drop their car off in a designated cabin and even take their keys with them. They would then have to validate their reservation at a kiosk where their flight information and parking can be confirmed. Once confirmed, the robot will go to the cabin and take their car by sliding underneath the car and using its arms to gently lift the car by its tires and moves it to a secure parking lot that is not open to the public [15]. When people get back from their flights, the robot will also take their car back to a cabin and have it waiting for them on their return. Stanley robotics has their solution applied in Gatwick Airport in the UK and Lyon Airport in France [16].

3.4.2 Smart Parking Ltd.

Smart Parking Ltd., based in Scotland and the UK, operates using a real-time sensor-based parking solution. Their target markets include universities, hospitals, airports, supermarkets, shopping centres, parking operators, and municipalities [17]. Their smart parking solution is a system made up of many components. SmartCloud is their web-based service platform that gathers and processes information and can provide tailored, real-time information and events of a site. Their app, Tessera, functions as

their compliance management system allowing businesses to manage parking compliance and enforcement. The app can also be used to show motorists real time guidance and payment options on an embeddable map to help pre-plan their journey [18]. Their sensors operate through an IoT gateway, allowing hundreds of devices within the system to provide data to the SmartCloud Platform. They use a sensor per spot method for their solution. Indoors, LEDs are placed overhead each spot which also function as their sensor. They turn green when the spot is empty and red when taken. Outdoors, they have a sensor placed in the ground that detects when a car is parked over it. They are currently adopted in 17 countries [19].

3.4.3 Cleverciti Systems

Cleverciti Systems, based in Germany with headquarters in Munich and Atlanta, created high-tech solutions for outdoor and on-street parking detection, monitoring and guidance. Their target markets include universities, hospitals, airports, stadiums, shopping centres, parking operators, offices, and municipalities. They provide a sensor-based solution that gathers information on available and occupied parking spaces in real time. Their sensor can cover up to 100 parking spaces and can be installed on existing infrastructure such as light poles or buildings [20]. Their sensors also measure the exact GPS position and size of open parking spaces. For space management they offer many tools to help clients such as real-time occupancy data gathering, maintain and provide visual data on actionable trends, and detecting floating spaces to control and monitor less defined parking areas [21]. For parking guidance, they can have the data obtained from sensors to be integrated into signage that guide drivers to available spaces, or mobile apps. Their data is available through their REST API that supports apps, smart city dashboards, or third-party systems [22]. Currently, their solutions are adopted in German cities such as Berlin and Cologne, North American cities such as San Antonio and Washington, and in the middle east in Dubai. Within Canada, they are in use at University of British Columbia (UBC) in Vancouver.

4 Finances

4.1 Cost Considerations

The tables below outline the cost for our PoC and functional prototype. The tables include the total cost with and without a reserve fund. For each period, a contingency has been calculated to account for any uncertainties. To calculate the contingency, we used a deterministic approach outlined by the Association of Advancement for Cost Engineering (AACE International) in which the reserve is calculated as a percentage of the base cost. AACE International recommends using their estimate five class system to calculate contingencies as it accounts for common project risks depending on the stage. [22]. Five being the most complete version of the project while one being the initial start-up.

The base price for our components is $397.78 with shipping being costly we must spend an additional $110.00. Our fully functional engineering prototype is estimated to cost $507.78; this includes PoC and functional prototype cost. Using this value, the reserve fund is calculated for each stage using the following formula below.

$$Contingency = Percentage \times \text{Overall } Estimate \tag{4.1.1}$$

Table 4.1: Contingencies Calculations

Prototype	Estimate Class	Percentage	Contingency ($ CAD)
PoC Prototype	Class 2	40%	203.11
Engineering Prototype	Class 4	20%	101.55

PoC prototype is assigned a class 2 since it requires quite a bit of research and testing for hardware and software, thus a higher percentage is allotted. The engineering prototype is assigned a class 4 since it is a functional assembly level product and requires less research and development.

Table 4.2: Proof of Concept Estimated Cost

Component	Description	Total Cost ($ CAD)
Raspberry Pi 4 Model B Kit	Raspberry Pi kit containing components needed to make the Pi functional	184.79
Raspberry Pi Camera Module	Camera module allowing the capture of images and videos with the Pi	15.99
DMX LED Dome Light	LED dome light capable of changing into any RGB color.	70.00
Total		**270.78**
Total including reserve		**473.89**

Table 4.3: Engineering Prototype Estimated Cost

Component	Description	Total Cost ($ CAD)
Higher Res Raspberry Pi Camera Module	Higher Res camera module allowing the capture of clearer images and videos with the Pi	107.00
USB Microphone for Raspberry Pi	USB microphone can be used for acoustic signal processing, voice recognition, musical instrument recording, or engineering applications in machine noise monitoring	52.54
Battery	Rechargeable battery pack for the system	80.00
Enclosure	Enclosure for device with mounting assembly	50.00
Total		**237.00**
Total including reserve		**338.55**

4.2 Funding

To fund our prototype, we have identified 3 major sources of funding that will cover our costs. The following 3 sources are described in the subsections that follow.

4.2.1 Engineering Science Student Endowment Fund (ESSEF)

The Engineering Science Student Endowment Fund or known as ESSEF, is administered and ran by the Engineering Science Student Society (ESSS). The fund is allocated to Engineering Science students based on 4 Categories. The following categories consist of Competition, Entrepreneurial, Class, and Miscellaneous [23]. We fall under two categories which is Entrepreneurial and Class. Obtaining funds from the respective categories should not be an issue as we meet all the criteria stated by ESSS. The team at OpenSpot will apply for this fund in the next semester (Fall Term, 2021).

4.2.2 Wighton Development Fund

The second source of funding we will apply for is from the Wighton Development Fund, administered by Dr. Andrew H. Rawicz. The fund is targeted towards projects that benefit society; However, all companies developing their prototype can apply to receive some funding. The team at OpenSpot will apply for this fund in the next semester (Fall Term, 2021).

4.2.3 Company Fund

The team at OpenSpot has accepted to provide personal funding, if needed, to cover the full or remaining cost of the prototype. Each member will provide $94.78, adding to a total fund of $473.90, which will cover the total cost of our PoC prototype, as stated in Section 4.1.

5 Project Planning

OpenSpot will follow and create the first two stages of the traditional three phases of product prototyping before production [24]. The project timeline is split into two, 4-month long periods where a prototype will be produced at the end. The primary features and functions to be presented at the end of each period are described in section 2.2 Project Scope. Table 5.1 below presents the details of each period and the resulting prototype. Since the work on the project will only last two semesters, the production prototype is unplanned will be considered in the post-mortem period after ENSC 440 (Fall, 2021).

Table 5.1: Prototype Periods

Period	Prototype
Summer Semester (May to August)	Proof of Concept
Fall Semester (September to December)	Engineering Prototype
Post-mortem	Production

The following page contains our schedule in the form of a Gantt chart (Figure 5.1) for the development of our system. Items listed in bold are the significant tasks with their subtasks listed beneath them. The Document and Presentations section (Task ID 1 to 11) of the chart only considers the deadlines presented in the first semester (ENSC 405W). The timeline will be updated once the second semester commences (ENSC 440), and deadlines are revealed. Also, the PoC prototype completion date is subject to change depending on when the presentation date is scheduled, and we will plan accordingly to ensure all the features and functions are ready. Diamonds represent milestones and the lines with arrows show the tasks they depend on.

ID	Task Name
1	**1 Documentation and Presentations**
2	1.1 Progress Review 1 Presentaiton
3	1.2 Project Idea Approved
4	1.3 Requirements Specification
5	1.4 Functional and Non-Functional Requirements Determined
6	1.5 Progress Review 2 Presentation
7	1.6 PoC Prototype Design Specification
8	1.7 UI/Appearance-Prototype Design Appendix
9	1.8 PoC Design Finalized
10	1.9 Project Funding Proposals
11	1.10 PoC Presentation and Demo
12	**2 PoC Hardware Module Development**
13	2.1 Research
14	2.2 Order Parts
15	2.3 Set up Pi and Camera
16	2.4 Basic Module and Peripheral Control
17	2.5 Develop Script to Control Camera
18	2.6 Set up Communication With Server
19	**3 PoC Backend Server Development**
20	3.1 Research
21	3.2 Technologies, Tools and Stack Chosen
22	**3.3 Computer Vision Application**
23	3.3.1 Detect cars and determine if spots are occupied
24	3.3.2 CV can use Pretrained Weights to Detect Cars and Spots in a Parking Lot
25	3.3.3 Connect CV Application to Web Server
26	**3.4 Web Server**
27	3.4.1 Set up Django Web Server Framework
28	3.4.2 Create CV API Module
29	3.4.3 Connect CV Application to Web Server
30	3.4.4 Handle Response from Module
31	**4 PoC Integration and Testing**
32	4.1 Integrate Hardware and Software
33	4.2 System Testing
34	4.3 PoC System Fully Integrated

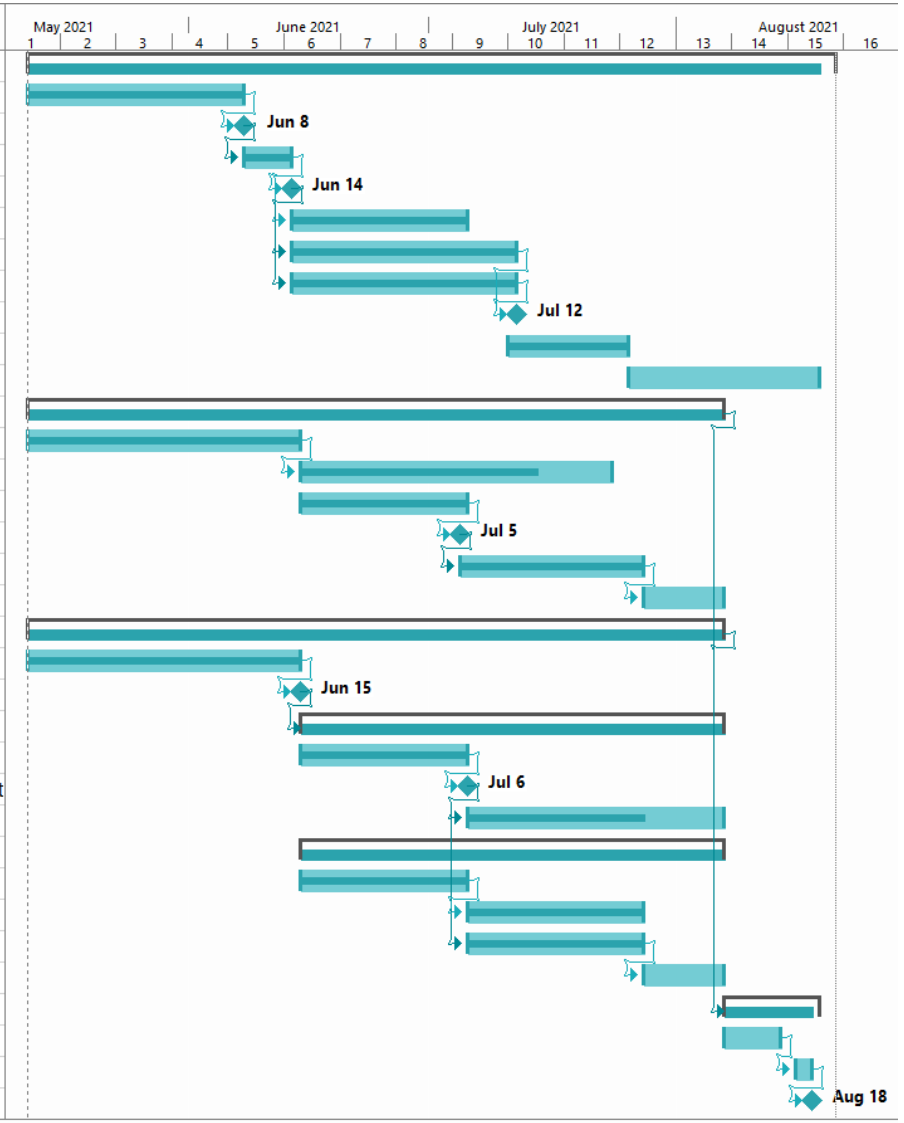


Figure 5.1: Gantt Chart for the Proof of Concept (May to August)

6 Company Details

Created on May 12, 2021, OpenSpot hopes to advance the world of smart parking and provide drivers with a stress-free experience in parking their vehicles. Using OpenSpot, users may simply access the website and find unoccupied parking stalls accordingly within the lot most suitable based on their destination.

6.1 Justin Naorbe – Chief Executive Officer (CEO)

Justin is a 5th year system engineering student with an interest in robotics and their potential areas for commercialization. He has had previous work experience as a Hardware Testing Engineer at Algo Communications and a Hardware Design Assistant with EIM Technology. At OpenSpot, he has been working on the hardware aspects of the OpenSpot module such as the LED lights and housing design. He will continue to actively optimize and perfect the module design through the alpha and beta stages. Justin is also OpenSpot's CEO and oversees all operation of the company and provides aid to the hardware team.

6.2 Soroush Saheb-Pour-Lighvan – Chief Technology Officer (CTO)

Soroush is a 5th year computer engineering student with an interest in machine learning and data science. He has had previous co-op placements, as an IT intern at a private school and an Embedded Systems Developer at Intel. At OpenSpot, he has been working on the backend server as well as the computer vision algorithm used for parking spot detection. In addition, he will be working on the front-end website used for the User Interface. Soroush is also OpenSpot's Chief Technology Officer (CTO) and in charge of providing support in all parts of the project if deadlines are not met.

6.3 Curtis Lui – Chief Communications Officer (CCO)

Curtis is a 5th year computer engineering student with interest in IoT and distributed systems. He has previous co-op placements at Sierra Wireless and Safe Software testing where he tested and developed software. At OpenSpot, he works on the backend server. His focus area is on the computer vision system as well as the communication between the server and the hardware module. Curtis is also OpenSpot's CCO and in charge of moderating the semi-weekly meetings and maintaining relations with SFU Parking.

6.4 Darius Nadem – Chief Information Officer (CIO)

Darius is a 5th year computer engineering student with an interest in areas including databases and server management. He has had previous work experience at Tantalus Systems as a Technical Support Engineer and Sierra Wireless as a Software Test Developer. At OpenSpot, he has been working on the hardware design aspect along with any necessary configurations involved with the Raspberry Pi module to ensure effective communication may occur with the backend server. He will also be working on the audio recognition application used to detect the presence of car alarms within parking lots. As the CIO, he will be involved in ensuring proper communication channels are established within the group along with providing support for the backend server members if needed.

6.5 Gurmesh Shergill – Chief Hardware Officer (CHO)

Gurmesh is a 5th year system engineering student with an interest in robotics and drones. He has had previous work experience at Mark Anthony Group as an IT Technician in PLC management and network solutions. He has a desire to learn more about PLC implementation in larger manufacturing applications. At OpenSpot, Gurmesh is the CHO. He is working on the hardware components of the smart parking system module and provides support to the CEO in material purchase decisions and mounting design.

7 Conclusion

This document has provided an overview of our smart parking system along with a discussion on areas such as project justifications (risks, benefits, competition, and market analysis), project planning, and company details. The document also outlines the need for our unique smart parking system and illustrates how cost effective it is compared to competition currently available on the market.

OpenSpot reduces installation costs for clients by using the existing infrastructure and cameras to cover multiple parking stalls, as opposed to conventional smart parking systems which utilize a sensor per spot. Demand for parking solutions will increase as populations continue to rise leading to more vehicles.

OpenSpot has an end goal in mind of alleviating the stress associated in finding open parking stalls within busy parking lots. The smart parking system makes use of cameras and a computer vision application to detect open stalls within lots, which will be displayed on a mobile friendly website for drivers to view in advance of their departure. In addition, there will also be an LED light indicator used to inform drivers of the current parking density state within the lot. Audio recordings will also be captured through a microphone and sent to the backend server for analysis through an audio recognition application to detect the presence of an active car alarm. If detected, this information will be relayed through the website to inform clients of the possibility of crime.

The website is a crucial component of our smart parking system, as it is the primary user-interface. It is used to relay individual parking spot information, of the respective parking lot, to users through an intuitive map displayed on the main page. In addition, peak hours are displayed to let the user know in advance before their departure. Furthermore, it will alert clients in the event of an active car alarm and damage to the module.

As a team of five determined and hard-working engineering students with experience in areas such as hardware, software development, and system design, we are excited to offer a system to advance the world of smart parking solutions. By meticulously following the schedule listed in the Gantt Chart, we expect to achieve a fully functional and marketable prototype.

We believe that potential clients will be eager to adopt our smart parking system based on the reduced costs of installation, added security measures, and the time-saving implication of our system. As smart parking continues to become increasingly popular around the world, the desire for potential clients to adopt our system will only increase in the years to come. The team at OpenSpot hopes to revolutionize the world of smart parking and provide users with an effective means to find an open spot.

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