Mar 28, 2019

Craig Scratchley

School of Engineering Science

Simon Fraser University

Burnaby, BC V5A 1S6

Re: ENSC 405W/440 Project Proposal for FoCoS (Forward **Co**llision Warning **S**ystem**) by TRAFEC**

Dear Dr. Scratchley,

The following document contains the project proposal of our project for ENSC 405/440: FoCoS. The goal of this project is to make an aftermarket front collision warning system for cars. The system will be designed to alert the driver in case of upcoming collision to prevent or reduce the severity of the crash. FoCoS will be of big advantage in high traffic area or when driver is unconscious which is the reason for most of the front collisions. Due to its object tracking technology, in addition to detecting collisions it can also be used for other applications like detecting pedestrians or other objects that can cause a crash.

This document will give introduction and background of our product, including the overview of our prototype. We will talk about the market competition, risk and benefits that comes with FoCoS, an overview of the project's timeline with relevant milestones. A summary of finances of product's cost, budget and potential funding will also be provided. Brief information will also be given regarding out company "Trafec" and each member of team with their skills and specializations.

Our team consists of 4 individuals who are passionate about finding solutions to traffic problem bringing safe and faster commute to people. Our team has Avneet Kaur, Abhishek Mahajan, Ranbir Makkar (CCO) and Amitoj Singh. If you have any questions or comments, please direct them to rmakkar@sfu.ca.

Sincerely,

Ranbir Makkar

Chief Communications Officer

PROJECT PROPOSAL

FoCoS (Forward Collision warning System)

Project Team:

Abhishek Mahajan

Amitoj Singh

Avneet Kaur

Ranbir Makkar (CCO)

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Submitted To:

Dr. Andrew Rawicz - ENSC 440

Dr. Craig Scratchley - ENSC 405W

School of Engineering Science

Simon Fraser University

Issue Date:

Mar 28, 2019

Executive Summary

There were approximately 6 million vehicles crashes in the U.S. in 2015. The collision warning and avoidance system can help cut the rates of injury crashes of the same type by 21 percent, according to the study. In March 2016, the National Highway Traffic Safety Administration (NHTSA) and the Insurance Institute for Highway Safety announced that manufacturers of U.S. automobiles agreed to include automatic emergency braking systems based on Forward Collision Warning as standard on virtually all new cars coming in the U.S. by 2022. In 2012, Europe had a similar agreement about advanced emergency braking system (AEBS) or autonomous emergency braking (AEB) [1]. Any FCW equipped vehicle is less prone to an accident and makes you and others feel safer on the roads but there are still many old cars running on the roads. They don't have such technology in their cars.

The FoCoS by TRAFEC is reliable, affordable, and trustable aftermarket solution for the cars that are not provided with such technology. Our product comes in 5 parts with a Radar, main unit with microcontroller and speaker, a camera, LED and adapter to power the main unit using car's power. The warning will be given at 2 different levels using LED and the speaker. The main goal of building this product is to bring safety to the roads by enabling an easy install of our product. Doing so we give the power to every individual without any technical knowledge make himself and other safer on the road.

TRAFEC is made up of 4 passionate engineers from Simon Fraser University with a goal to make road journey safer. With work experience spanning from IT, testing, software developing and machine leaning our team bring great skillset to make this reality. All these experiences will contribute to project at different production level making sure product building process has been followed. Beside all this, machine learning will also help us implement object detection enabling us to bring more out of our product.

Glossary

Closing time	Time required for the collision to occur based on the relative speed of 2 objects and the distance between them
Frontal object	Any object in front of the car is considered as Frontal object. It could be any vehicle, pedestrian or other stationary body
Subject Vehicle	Vehicle equipped with FoCoS
Audio Alert 1	600Hz sound at a rate of 1 beep/sec
Audio Alert 2	600Hz sound at a rate of 2 beep/sec
User	Driver of the subject vehicle

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1 Introduction

Car automation technology has made a significant growth in the past few years. The autonomous vehicle technology is comprised of many technologies such as automated braking system, forward collision warning (FCW) system, Back-up camera and collision warning, and many more. The whole purpose behind this automation is to make people more secure on the roads, no matter if you are inside the car or outside the car. Since most of these technologies are only available in the new cars that came out in the recent years, at TRAFEC our vision is to bring Forward collision warning system as an aftermarket solution to the older cars. FoCoS is completely based on the idea of FCW and we are hoping to help people with cars that are not equipped with such technology.

The National Highway Traffic Safety Administration estimates that 16% of fatalities and 20% of the injuries in the U.S. involved driver distraction [1]. Also, the statistics from ICBC revealed that in 2013, 29% of the fatal accidents were caused by distracted driving [2].

FoCoS will provide an audio and visual alert to warn the driver about the risk of collision. FoCoS will use an on-board sensor that detects the frontal object and the system that will determines the possibility of the crash.

This proposal will discuss existing aftermarket forward collision warning systems and how we will be implementing our product. Further a high-level overview of our product including risks and benefits, as detailed in section 2 will be provided. The market and competition will be examined in section 3. List of milestones and our project outline will be presented in Section 4. Finally, section 5 will discuss the costs of each component needed to build the prototype and a rough estimation of the required funding amount.

2 Project Overview

2.1 Background

FCW is an automobile safety system intended to reduce the severity of a crash. FCW detects an imminent crash by sensing the frontal objects and provides warning to the driver of the car. Below are some of the common situations where FCW can be helpful:

- Car in front of you has stopped at green light due to an obstacle in front of it and you're travelling too fast towards it
- You are looking at your infotainment system and the car ahead accidently pressed brakes
- The vehicle ahead suddenly slows down to turn without giving signal
- You do not notice the car in front pressed brakes due to bad weather and/or low visibility

All the problems listed above have the potentials to put drivers at the risk of collision. Any FCW equipped vehicle is less prone to an accident and makes you and others feel safer on the roads. But there are still many cars running on the roads, and they don't have such technology in their cars.

Our team came up with this approach of creating an aftermarket forward collision warning system. It will be using RADAR and camera to sense the frontal objects. FoCoS comes with an inbuilt speaker but can also be integrated to car's sound system (may be an external speaker depending on the car) to provide audio warnings and a head's up display will provide the visual warning.

2.2 Scope

The goal of the FoCoS is to bring the forward collision warning system into the cars that are not equipped with this technology, doesn't matter if it's an old or a new car.

FoCoS is a compact device which consists 3 main units:

Detection Unit- 1 radar sensor and 1 camera
Processing unit- 1 microcontroller
Alert Unit- 1 head-up LED and 1 audio output.

The detection unit will be connected to the front of the car to sense the frontal object (car or pedestrian) incase it's too close to the vehicle. A warning will be sent out to the driver using the head-up display and subject car's audio system.

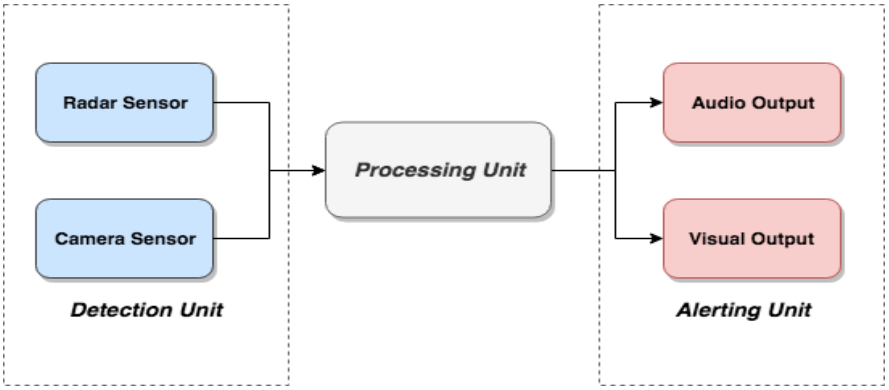

FIGURE 2-1: BLOCK DIAGRAM OF FOCOS

2.3 Risks

2.3.1 Environmental conditions

FoCoS has 5 main components: The micro-controller, camera, speaker, LED, and RADAR sensor. Except the RADAR sensor none of the other components are exposed to the outside environment. RADAR will be installed on the front of the car enclosed in the proper cover, but it is still at the risk of catching dust and water from the outside environment. Sensor will need to be remained clean for the proper functioning and get the accurate reading.

2.3.2 Installation

Installation is the most crucial step of our product. The sensor must be installed very carefully to get the readings correct. Because we are measuring closing time in the seconds, so the sensor must produce the accurate data. Also, it should be placed in such a position where the waves are not blocked in any way. An installation guide will be given to the user with the proper instructions based on the car they're going to install FoCoS on. As safety is the most important aspect of the product, we'll make sure it can't be compromised in any way.

2.4 Benefits

2.4.1 Safety

FoCoS will always be looking at the front of the car and without any distraction it's constantly working when the car is running. If it senses any object which could be dangerous and could lead to a crash, it's going to give the user a warning in 0.2 seconds. FoCoS provides a safety and security to the user.

With the car equipped with FoCoS, it will give a sense of relief to the users of the car. They will have a peace of mind while driving that there is a system that is watching over any possibility of collision. Even if they lend their car to someone else, FoCoS assures them that their loved ones are safe in the car.

2.4.2 An upgrade

Car technology advances so quickly and those driving older vehicles can end up feeling left out. FoCoS will bring a technology upgrade to an existing car. It will make an old car feel like new and will increase the life span of car. It can save the money of the users who feel to upgrade their car just because their car lacks technology.

3 Market and Competition

3.1 Competition

Aftermarket Forward Collision Warning Systems are readily available in today's market. However, these systems either rely on non-radar sensors, which are not as reliable in all-weather conditions, or are much more expensive than FoCoS. At TRAFEC, we are aiming to build a reliable forward collision warning system using a radar as our main sensor, which ensures that FCW will work in all weather and low visibility conditions; and a camera for object detection, which will allow our product to differentiate between pedestrian, vehicle or an object; while keeping product affordable. Some of the major competitors for FoCoS are Mobileye and Safe Drive Systems (SDS).

3.1.1 Mobileye

Mobileye (model 560) (Figure 3-1) offers an all-in-one camera system, featuring an in-vehicle display, forward collision warning; urban forward collision warning, which operates at speeds below 20 mph; pedestrian forward collision warning; headway monitoring and warning, which measure following distance at speeds above 19 mph; lane departure warning; and a speed limit indicator, which displays the road speed limit [3]. The key differences between this product and FoCoS are (1) the lane departure warning system, which can be added to our product at a later time since it is already equipped with a camera; and (2) the cost of the product. The Mobileye costs over $1000 and requires professional installation. In contrast, FoCoS is aimed to cost about half of that price and will be installable by the user.

FIGURE 3-1: MOBILEYE MODEL 560, SOURCE: AMAZON.CA

3.1.2 Safe Drive Systems (SDS)

SDS is a leading developer and distributor of advanced after-market auto technology [4]. The RD-140 System (Figure 3-2) offered by SDS provides forward collision warning as well as

lane departure warning system. RD-140 is equipped with a display unit, providing visual and audio warnings, a radar sensor for FCW and a camera for lane departure warning. Based in US, this product is currently priced at 1900 USD on Amazon, almost four times the price of FoCoS. Hence, the affordability of FoCoS is our major advantage over this product.

FIGURE 3-2: RD-140 BY SAFE DRIVE SYSTEMS, SOURCE: AMAZON.CA

3.2 Market

The target market for FoCoS will be older cars that are not equipped with new tech, as well as newer and cheaper car models that do not have in-built Collision Avoidance Systems. Market research shows that the global collision avoidance sensors market size was valued at USD 4.39 billion in 2017 and is expected to exhibit a compound annual growth rate of 21.2% from 2018 to 2025 [5]. In addition, market share for radar-based sensors is projected to account for 44.5% of the global market by 2025 [6]. Also, the FCW system segment is expected to account for a major market share by 2025 since it helps in significantly decreasing rear-end collisions or accidents. The following figure 3-3 shows the market share division in Europe by application.

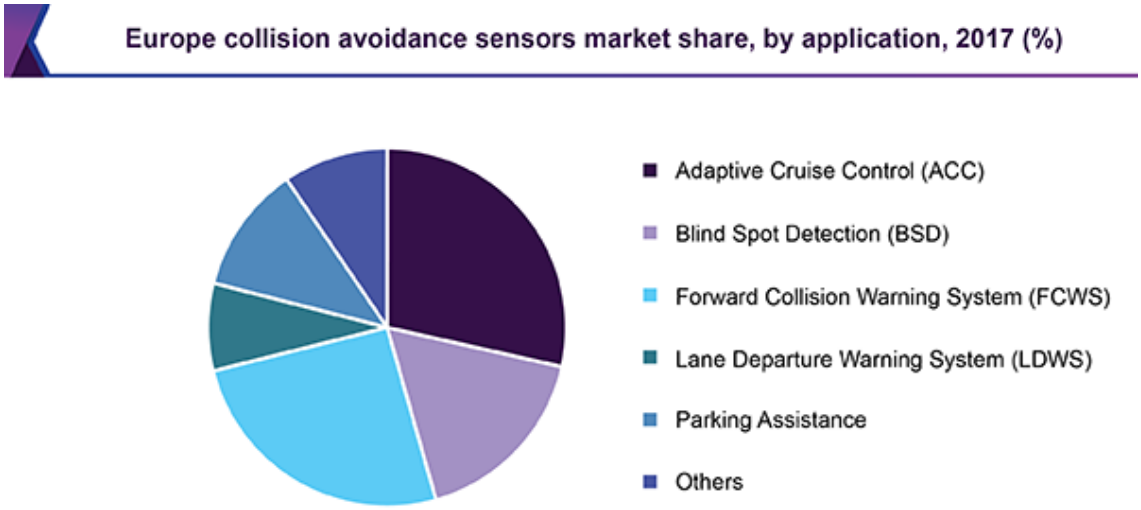

FIGURE 3-3: EUROPE COLLISION AVOIDANCE MARKET SHARE [5]

With increasing developments in sensor technology, including camera, lidar, radar and ultrasound, the market has witnessed rapid growth over the last few years. As a result, an increasing number of vehicles are now being produced equipped with safety systems packages.

This increase in available collision avoidance systems in new vehicles has led to an increase in demand for aftermarket collision avoidance systems such as FCW, Lane Departure Warnings, Dash-Cams, Pedestrian Warnings, Backup Cameras, Parking Assistance and Blind Spot Detection. The currently available after-market Forward Collision Warning Systems are quite expensive and require professional installation. Hence, the reliability, affordability and ease-of-installation of FoCoS makes it a highly useful, desirable and user-friendly product.

4 Project Timeline

Figure 4-1 and Figure 4-2 show our project's Gantt and Milestone Chart respectively for the timespan of January to May.

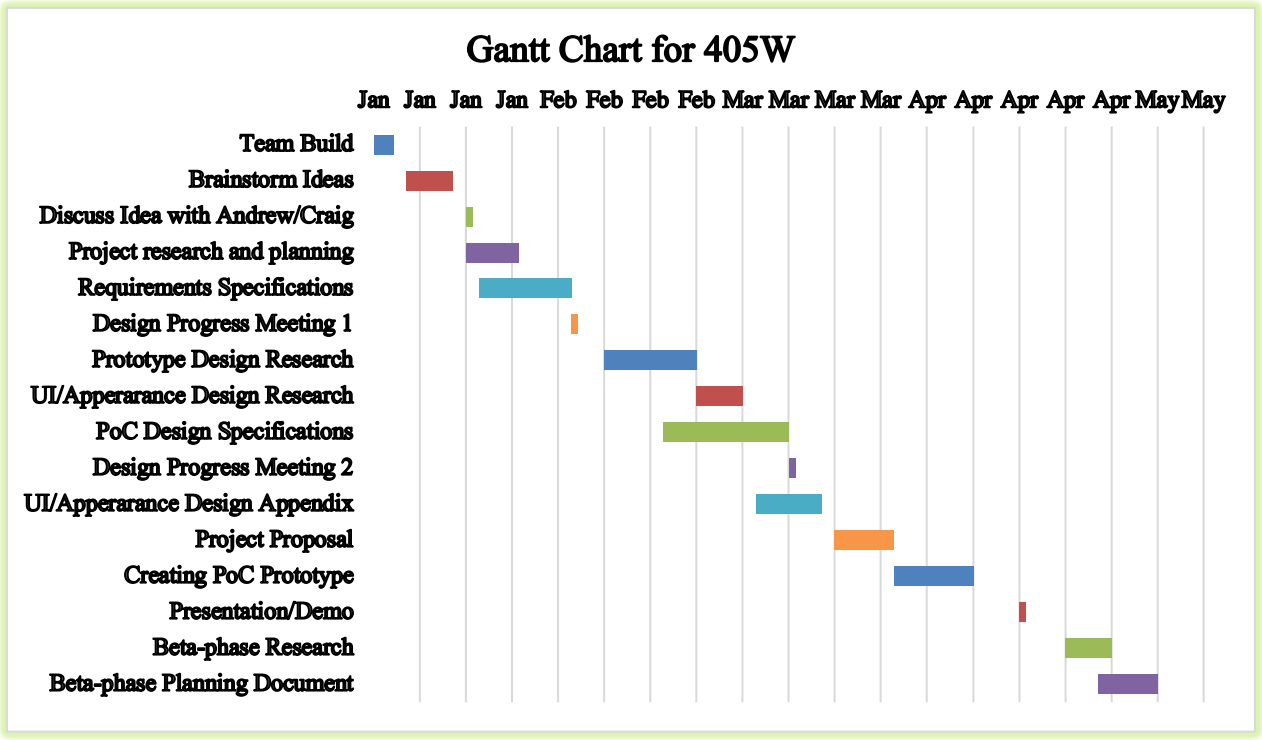

FIGURE 4-1: GANTT CHART

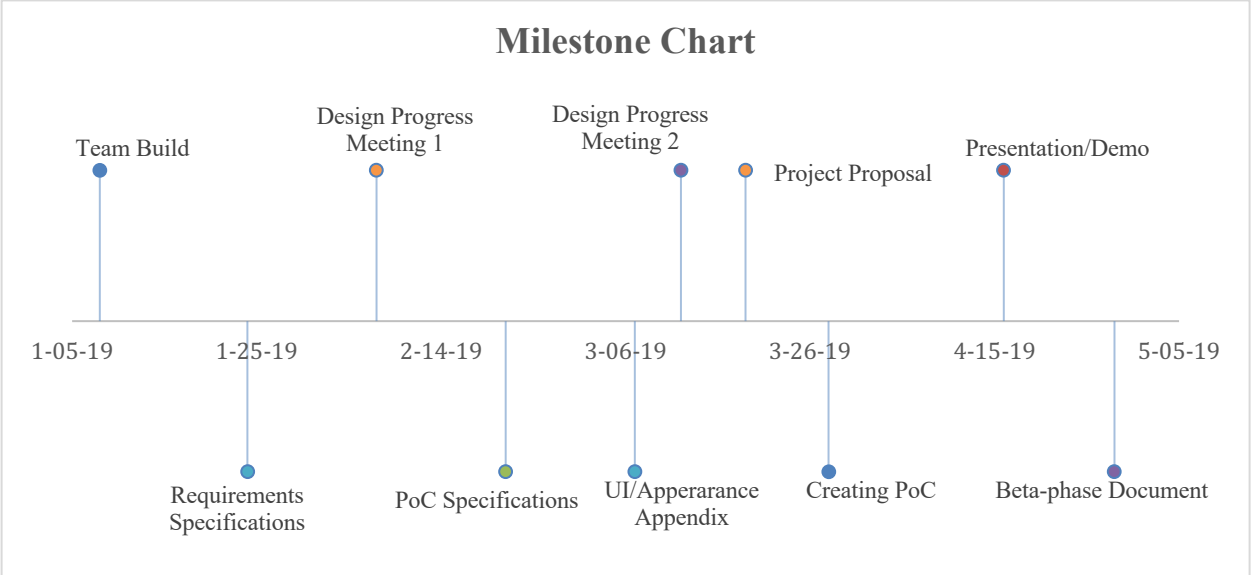

FIGURE 4-2: MILESTONE CHART

5 Finances

5.1 Project Cost

The estimated cost of building our product FoCoS are based on components ordered from amazon or other common electronics distributors (see appendix for the list of vendors). The price show will include the cost of the prototype and an approximate cost for the final production of product at large scale. These prices won't reflect the cost of leasing building cost, labor cost, production equipment costs and consumable costs.

The prototype will be constructed using off the shelf parts to reduce the cost and ensure compatibility between different components. Small range Radar and cheaper camera will be used to test our concept and in prototype which will gives us the advantage to easily swap components if we find something is not going with our design specifications.

The table below show the cost of various parts used in prototype:

Prototype Production Cost		
Component	**Description**	**Price (CAD)**
Raspberry Pi 3 B+ package for research and final prototype	Microprocessor with SD card, HMDI cable	$90
Radar	Smaller radar with 7m range	$10
Mini External USB 2.0 speaker	Speaker for audio alert	$20
LED	Single red LED for visual alert	$2
Resistors, wires etc.	Various components needed for audio and other module connections	$15
Camera	Keyestudio Camera Module 5MP REV 1.3 compatible with Raspberry Pi 3 Model B+	$15
Other	Taxes, Shipping and Handling etc.	$45
Total:		$197

TABLE 5.1: PROTOTYPE PRODUCTION COST

5.1.1 Raspberry Pi 3 B+

Main processing unit of our product, where all the input comes in from camera, radar and feedback is provided. This will be inside the car where all the connections to components will be made, so it should be small enough, so it doesn't occupy a lot of space.

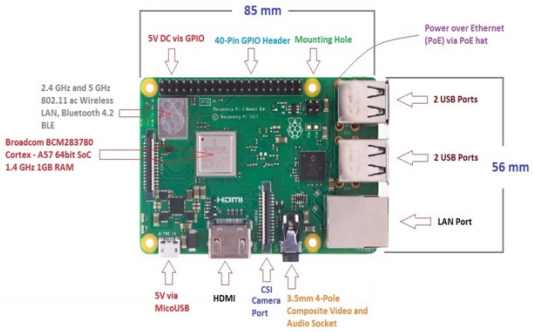

FIGURE 5-1:RASPBERRY PI 3 B+ [7]

5.1.2 Raspberry Pi Camera

This is the eye of our system, capturing and identifying the cars and other things in front or around the car. With the object detection our system can be more precise in figuring out false detection by radar if any.

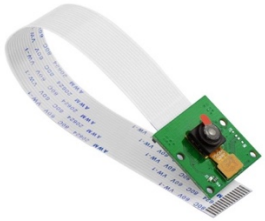

FIGURE 5-2:RASPBERRY PI CAMERA MODULE [8]

5.1.3 Radar Sensor

Sensor that will be detecting the object within 25m of the car (7m for prototype). This will help us identify the closing time between the car and the object in front of it. Using this information, we will identify which alert to give audio or visual (depending on the closing time).

The table below show the cost of various parts used in final product:

Final Production Cost		
Component	**Description**	**Price (CAD)**
Raspberry Pi 3 B+ package for research and final prototype	Microprocessor with SD card, HMDI cable	$90
Radar	Expensive Radar with range of 25m	$220

Mini External USB 2.0 speaker	Speaker for audio alert	$20
LED	Single red LED for visual alert	$2
Resistors, wires etc.	Various components needed for audio and other module connections	$20
Camera	Keyestudio Camera Module 5MP REV 1.3 compatible with Raspberry Pi 3 Model B+	$15
Other	Taxes, Shipping and Handling etc.	$60
Total:		$427

TABLE 5.2: FINAL PRODUCTION COST

5.2 Potential Funding

The initial cost in the design and making of this project will vary with the number of units produced in the development, and it is also important to note that initial capital required will exceed the cost of the finalized product. To ensure the success of the product and achieve our goals, it is required to have and apply for funding source.

Following are the funding sources we would be applying for:

- The Engineering Science Student Endowment Fund is awarded by SFU's Engineering Science Student Society (ESSS). Our prototype is entrepreneurial and therefore meets the funding criteria
- Wighton Engineering Development Fund, administered by Andrew Rawicz, is typically awarded to projects benefiting society. As mentioned previously, our product aims to improve road safety and accidents, which is a great benefit to society. We will apply for this fund during this semester

6 Company Overview

6.1 Abhishek Mahajan, CEO

Abhishek Mahajan is a fourth year Computer Engineering student from Simon Fraser University. Passionate about bringing traffic solution to enable people reach their destination safer and faster, he has strong skills in machine learning, embedded programming and languages like C++, Python and VHDL. Abhishek has experience working with OpenCV and Caffe to detect objects and also working with python scripts to automate process and machine learning. He has also love developing software that brings positive change to society or help them in some way.

6.2 Avneet Kaur, CTO

Avneet Kaur is a fifth-year Computer Engineering student at SFU with an interest in image processing and embedded systems. As a Firmware Developer Co-op at Avigilon, she created a driver for a Pulse-Width-Modulation LED for an intercom camera while working in an Agile Team. Avneet has extensive experience in coding in various languages such as C, C++, Python, Java, MATLAB, JavaScript, HTML, CSS, PHP and VHDL. Outside of Engineering, Avneet has interests in Robotics and has experience teaching Lego Mindstorms, Scratch and Java to kids aged 5-14 years.

6.3 Ranbir Makkar, CCO

Ranbir Makkar is a 4th year Computer Engineering student. He spent 1 year working with Thales Canada as an IT Security Analyst and 4 months with Simon Fraser University as a Research Associate. While doing co-op at SFU, he gained experience in working with micro-controllers. Ranbir has a good understanding of various programming languages such as Python, C++ and C. Ranbir is also familiar with 3D CAD design and has experience in Free CAD.

6.4 Amitoj Gill, COO

Amitoj Gill is a 4th year Computer Engineering student at SFU with an interest in Machine learning and Embedded systems. He has completed 8 months of co-op in Avigilon and another 8 months of co-op in Sierra Wireless where he helped create, update and maintain automated test scripts in Python. Also, recently Amitoj contributed to a group project where they built a BlackJack game beater using CNN and RNN in Python. He is proficient in C++, C, SQLite and VHDL as well. Other interests that he has are playing soccer and hiking.

7 Conclusion

FoCoS is a small and intelligent device that will help user in navigating the roads more safely. By having a radar and a camera always looking for an obstacle, FoCoS will add an extra layer of security in the car. In addition to increasing driver security, FoCoS also makes the roads safer for other cars and pedestrians. The best part about FoCoS is that it is an inexpensive device which makes it available to everyone in need of such a device.

Having done an in-depth risk assessment, we understand that our major risks in developing a reliable FCW system are preventing radar sensor from environment conditions so as to get consistent, accurate readings. In addition, we will also need to make sure that we provide very clear installation instructions for users, since the calibration of both camera and radar are essential for a useable FCW.

Our team consists of 4 driven engineers who are passionate about finding solutions to traffic problem bringing safe and faster commute to people. We are excited to propose and build this highly useful and affordable product for our Capstone Project. With increasing demand, improving technology and lack of affordable FCW in current market, we believe our project has the potential to be a successful commercial product.

8 References

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9 Appendix

9.1 List of Prototype Vendors

Raspberry Pi 3 B+

Raspberry Pi Camera Module

LED- Borrowed

Radar with 7m range

9.2 List of Final Product Vendors

Every product used will be the same, only the Radar will be different with better range

Radar with 25m range