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Assessing Pedestrian Safety Conditions on Campus

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ASSESSING PEDESTRIAN SAFETY CONDITIONS ON CAMPUS

by

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A thesis submitted in partial fulfillment of the requirements
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ABSTRACT

Pedestrian-related crashes are a significant safety issue in the United States and cause considerable amounts of deaths and economic cost. Pedestrian safety is an issue that must be uniquely evaluated in a college campus, where pedestrian volumes are dense. The objective of this research is to identify issues at specific locations around UCF and suggest solutions for improvement. To address this problem, a survey that identifies pedestrian safety issues and locations is distributed to UCF students and staff, and an evaluation of drivers reactions to pedestrian to vehicle (P2V) warning systems is studied through the use of a NADS MiniSim driving simulator.

The survey asks participants to identify problem intersections around campus and other issues as pedestrians or bicyclists in the UCF area. Univariate probit models were created from the survey data to identify which factors contribute to pedestrian safety issues, based off the pedestrian's POV and the driver's POV. The models indicated that the more one is exposed to traffic via walking, biking, and driving to campus contributes to less safe experiences. The models also show that higher concerns with drivers not yielding, unsafety of crossing the intersections, and the number of locations to cross, indicate less safe pedestrian experiences from the point of view of pedestrians and drivers.

A promising solution for pedestrian safety is Pedestrian to Vehicle (P2V) communication. This study simulates P2V connectivity using a NADS MiniSim Driving Simulator to study the effectiveness of the warning system on drivers. According to the results, the P2V warning system significantly reduced the number of crashes in the tested pre-crash scenarios by 88%. Particularly,

the P2V warning system can help decrease the driver's reaction time as well as impact velocity if the crash were to occur.

ACKNOWLEDGEMENTS

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CHAPTER 1: INTRODUCTION

The University of Central Florida (UCF) prides itself on being one of the nation's largest universities, and enrollment is projected to increase by 3-5% per year. With this dense population the concern of pedestrian's safety is adamant. To thoroughly assess the specific pedestrian safety issues around UCF, this research study aimed to identify problem areas and pedestrian safety issues, as well as provide solutions. This study aims to investigate pedestrian safety at UCF via a survey and evaluate P2V communications via a driving simulator study as a solution. The reason for this study is to prevent the great amounts of congestion and vehicle accidents that threaten the safety of the vast number of pedestrians near UCF. Pedestrian safety is a focus for the university, as pedestrians and bicyclists are the most vulnerable road users.

The survey that was created includes 32 questions about participants opinions on several safety scenarios, their personal information, their experience as a pedestrian interacting with vehicles, their usual trip duration, and their trip path. For this study, a pedestrian is in referral to students or faculty and staff members of the University of Central Florida whom walk or use a bicycle on campus. By evaluating the behavior of both pedestrians and drivers, the survey will provide understanding on how to improve road safety for everyone and how driver's and pedestrians can relate to each other in a safer and understandable way. Meanwhile, to ensure a non-biased survey population, several types of media will be used to distribute the surveys. The survey asked about 26 specific intersections on UCF campus as shown in Figure 2: UCF Intersections Map. Issues at specific locations were identified and solutions were proposed. A pedestrian safety evaluation models from the pedestrian/cyclist point of view and drivers' point of view was estimated using binary probit modeling based on data collected from the survey. The

objective of the univariate probit models was to determine the level of pedestrian and bicyclist safety around campus and identify the factors that contribute to safety issues.

As the field of transportation advances, many pedestrian crashes can be avoided with emerging technologies. P2V was stuidied in depth as a pedestrian safety solution. Pedestrian-to-Vehicle (P2V) technology is a connected-vehicle technology that provides a solution to improve pedestrians safety, since it notifies a driver of the location of a nearby pedestrian. The purpose of this study is to eliminate avoidable crashes near campus by relaying the driver's attention to immediate surroundings when a pedestrian is crossing the road. P2V can assist when drivers do not see a pedestrian due to distraction, such as cellphone use, or obstructions in the drivers line of sight, such as a wall blocking view of the pedestrian or a sudden pedestrian dash out. In the study, if a pedestrian's location trajectory is in interference or proximity with the driver's location, the driver is notified via auditory warning and a warning message from the Head-up Display (HUD) on the simulator's screen. Fourty-seven participants drove in 2 scenarios each. The independant variables that were analyzed were Number of Collisions Avoided, Brake to Maximum Brake Time, Mean Decceleration, Minimum Distance, and Maximum Decceleration. Participants were recruited for all ages and gender, with the requirement of having at least one year of driving experience. The scenarios included blocks with and without warning systems that included unpredictable pedestrian scenarios.

1.1 Background

Acccording to statistics released by the latest National Highway Traffic Safety Administration (NHTSA) fact sheet, pedestrian deaths due to vehicle crashes are rising. Pedestrian deaths contribute to great economic loss. While pedestrians can take safety measures to avoid

being in a vehicle crash, such as crossing at the crosswalk during the crossing signal, pedestrians can not avoid the fact that around 65 % of all road accidents are due to drivers error such as driving under the influence of alcohol, changing lanes without signalling, driving on the hard shoulder and running a red light (Olarte 2011). The University of Central Florida Police Department (UCFPD) statistics state that 42% of 2017 crashes were due to careless driving, followed by speeding. The United States Department of Transportation (USDOT) has identified the strong need to perform research on vulnerable road users and connected vehicles.

The current and popular solution to pedestrian safety issues is P2V communications, which is a system in which the vehicle can sense the environment around it and communicate to other vehicles, infrastructure, and cell phones. It is predicted that this technology will reduce nonoccupant vehicle crashes by 80 %. The current technologies do not provide safety, mobility, and environmental advancements that this connected vehicle communication will provide. Pedestrian detection systems involve in-vehicle systems for the drivers and handheld devices for pedestrians (Kevin at. Al.). The gap in research which this study aims to fill is to quantify how much the P2V technology could reduce crash risk for pedestrians in areas identified as problems for college users, and in more specific, how much crash reduction would occur at different problem locations such as the intersection and the arterial. This research will also suggust improvements for current UCF areas with pedestrian safety concerns and relate survey responses to P2V driving simulation results.

1.2 Objectives

The primary objective of this research is to identify the locations with safety problems around UCF for pedestrians' safety and analyze drivers' response towards a P2V warning system, as well as identify other solutions. Specifically, it is desired to observe the following:

1. What are the problems and problem intersections for pedestrian safety around UCF from the pedestrians and drivers' point of view?

2. What are the solutions to these safety issues?

3. How does a driver's speed, breaking, and other behaviors change with the use of a P2V warning system?

1.3 Tasks

In order to complete this thesis, there were the following tasks to undergo:
1. Perform a thorough literature review.

2. Data collection and analysis.

3. Create univariate probit models for the survey data to compare pedestrian safety issues from the point of view of drivers with that of pedestrians in order to form a comprehensive solution to pedestrian safety issues in the study area.

4. Conclusions and recommendations.

1.4 Thesis Organization

This thesis is divided into six chapters as seen in Figure 1. The first chapter presents an introduction to the research, including background information, objectives of the research, tasks, and the organization of the thesis.

Chapter 2 includes a literature review covering the current research and findings related to the topic of the thesis. Specifically, it covers findings on pedestrian safety issues, pedestrian safety solutions, pedestrian safety surveys, as well as simulation studies. Additionally, study objectives and methodologies are also reviewed and discussed in this chapter.

Chapter 3 reviews the campus survey and relevant data. This chapter also provides details for the creation of the survey questions, distributions, and the efforts behind it.

Chapter 4 discusses the experimental design for the P2V driving simulator experiment, including the list and details of scenarios used. This chapter also covers the population sample used, as well as how the scenarios are structured in the simulation, the apparatus, and general findings from preliminary statistics.

Chapter 5 presents the data analysis for the campus survey using a linear regression model. There were two models created, one from the pedestrians POV and one from the drivers POV about pedestrian safety in the study area (UCF).

Chapter 6 contains the conclusions, research recommendations, solutions, and possible future studies that are found from the data analysis.
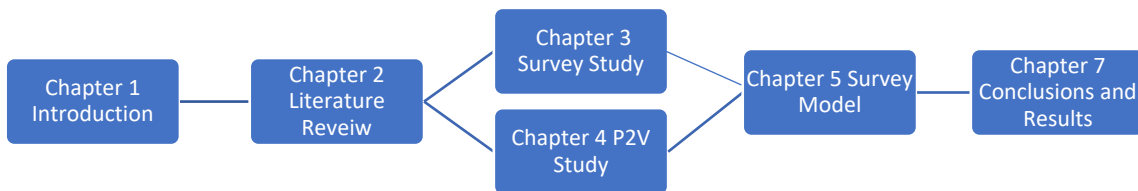
Figure 1: Thesis Organization

CHAPTER 2: LITERATURE REVIEW

2.1 Pedestrian Safety

Active modes of transportation in urban areas are on the rise. Walking and cycling are encouraged to advance public health and sustainability and to relieve traffic congestion issues and greenhouse gases. However, pedestrian safety is a concern, especially for urban areas, such as college campuses. The percentage of nonoccupant fatalities has risen in the past years, despite the number of roadway fatalities declining (Retting et.al., 2003). Pedestrians and bicyclists are classified as vulnerable road users, and most times the roadways are built in favor vehicles. Pedestrian safety issues have been widely studied in the past, with greater attention recently with the introduction of autonomous vehicles.

2.1.1 Pedestrian Safety Issues for Campus

College campuses are made up of a dense pedestrian population and many novice drivers. On the UCF main campus in 2016, UCF Police Department (UCFPD) responded to 370 written up traffic crashes and 211 hit-and-run crashes in. Fall and spring semesters had the highest crash count, possibly due to larger number of students on campus at that time. The spring semester crash rates accounted for 32.4% of total crashes in 2017 and rose to 67.5% in 2018. Forty-two percent of the crashes were due to careless driving, followed by speeding. Despite the university being widely accessible to nearby housing and shopping, pedestrians must be protected from the young and sometimes distracted drivers on the roads.

The safety of a university depends on the security of its students, staffs, and faculty. Every sidewalk and roadway are designed to meet the criteria required; however, the design for such roadways must have additional factors when being implemented on a college campus due to the

heavy traffic and spatial needs. UCF is alongside two heavily used roads, McCulloch Road and Alafaya Trail. University housing, shops, restaurants, and bars are conveniently located just across the street from campus. Walking and biking to these areas of interest is common, however, the roadways here have a speed limit of 45 miles per hour. The statistics have shown that when a pedestrian is hit with a vehicle at 45 mile per hour, the chances of survival are 50 percent on average and if a pedestrian is hit by a car at 25 miles per hour, the chances of survival are 91 percent on average ("Speed Limit on Streets", 2016). Lowering the speed limits could save lives.

In addition, some stretches of road along UCF, such as McCulloch Road, have crosswalks almost a mile apart. There was a lack of research done on the probability of jaywalking in relation to the distance between crosswalks. However, according to Florida Statutes 316.130 on Pedestrians; traffic regulations, it is clearly stated that between adjacent signalized intersections, pedestrians shall not cross at anyplace except in a marked crosswalk ("Florida Statutes", 2018). At UCF, students who jaywalk could be charged a $62.50 fine if caught by law enforcement on campus. This jaywalking fee started after a student was hit while jaywalking in front of the UCF gym.

Vulnerable road users (VUR's) are at risk to traffic fatalities and injuries, especially when pedestrians are in small numbers (Lee et.al., 2019). The proximity of crosswalks is an issue as well as proper sidewalks and lighting. Biking is a common means of transportation near a college campus. At UCF, some classes end after it is dark outside. Students also may bike to dinner or the store at nighttime. In Florida, 3% of bicycle usage takes place during nighttime hours, but nearly 60% of fatal bicycles crashes occur during this time. Two common causes of bicycle accidents are the failure to yield the right-of-way, and riding against traffic ("Bicycle Safety Tips"). McCulloch

Road, leading to campus, does not have a bike lane on either side of the road or a sidewalk on one side of the road.

The campus police are actively enforcing safe driving laws on campus, but pedestrians still behave in unsafe ways, such as by jaywalking and distracted walking. Pedestrians are often engaged in multi-tasking, such as using hand-held devices, listening to music, or eating while walking. There has been a positive correlation between unsafe walking behavior and distraction. Distracted walking has not received any policy or safety initiatives like distracted driving has. Tips to pedestrians include avoiding wearing headphones, talking on the phone while crossing a street, keeping volume low, and being aware of traffic (Mwakalonge et.al., 2015). Distracted pedestrians have shown unsafe behaviors such as walking against traffic lights or failing to look both ways before crossing. In addition, pedestrians tend to walk slower when on their cellphones, increasing their exposure to traffic (Hatfield et.al., 2007).

2.1.2 Pedestrian Safety Impacts

Every year over 1.35 million people die in traffic accidents. In 2017, 37,133 of the casualties around the globe were pedestrians. In the years of 2015 and 2016, pedestrian fatalities were on the rise. Fortunately, from the year of 2016 to 2017, there was a 1.8% decrease in pedestrian fatalities in all segments of population except crashes of large trucks and SUV's, in which there was a 18.7% increase in single unit trucks. A new occurrence was that the number of urban fatalities outweighed the number of rural fatalities. Urban fatalities increased by 17.4% since 2008 and rural fatalities decreased by 18%. According to the Census Bureau, urban population increased by 12.7% and rural population decreased by 11.8% from 2007 to 2016. The proportion of nonoccupant fatalities has increased to 33%, a record high, since 1996 ("Pedestrian Traffic

Safety Facts", 2017). Due to the rise of urban population there are more inhabitants and pedestrians in cities where traffic is dense.

Economic costs for traffic crashes in the United States in 2010 was $836 billion. Pedestrian crashes in 2010 contributed $65 billion to the $836 billion in economic inclusive cost for motor vehicle crashes. The highest fatality rate was for males ages 50-54, accounting for 4.22 pedestrian fatalaties per 100,000 people. A 9% increase in pedestrian fatalities were observed from 5,495 deaths in America in 2015 to 5,987 deaths in 2016. Pedestrian deaths accounted for 16% of motor vehicle crash fatalities in 2016. Interestingly, 70% of pedestrians killed in 2016 in traffic crashes were male. The most common hours for these deaths were from 6 am to 7 am and 3 pm to 4 pm (National Highway Traffic Safety Administration, 2016).

Pedestrian studies in the past have focused on the pedestrian route choice and crossing behavior on roads. A challenge when studying pedestrians, is that pedestrian behavior is unpredictable. Pedestrians may cross the street at any location, despite a fence or barrier in place. Pedestrian safety in urban areas, such as cities and college universities need special attention. It should be noted that drivers and pedestrians typically have different values of travel time, among other differences (Bansal, Kockelman et al. 2016). This thesis is based on pedestrian and drivers experience and solutions specific to college campuses. This experiment also includes scenarios where the driver encounters a pedestrian in an urban arterial or intersection in an unexpected manner, which was not studied closely in the past.

2.1.3 Pedestrian Safety Solutions

Pedestrian trips are taken for recreation and exercise, walking to take a bus/shuttle, walking between parking spaces and front door destinations, and walking as a means of transportation. Urban planners often consider alternatives during roadway design to improve the safety of

pedestrians, as pedestrians are the most exposed and vulnerable road users to traffic crashes. Solutions range from redesigning the sidewalk and roadway, such as in complete streets, adding safety technologies, such as a crosswalk with a rectangular rapid flashing beacon, or using new connected technologies, such as P2V.

Rodriguez-Seda and Benekohal investigated traffic safety in big ten university campuses in 2008. They suggested to reduce the number of parking spots or prohibit freshman from parking on campus, as well as removing vehicles from the core of campus and creating cheaper parking with transit along the campus perimeter. Less cars and congestion mean a lower chance for a crash. UCF has initiated "Park and Ride" to sway students from parking in the congested parking garages. Park and Ride allows students to park in the softball fields on campus outskirts and be bused into the heart of campus.

Certain roadside safety items, such as signage or lights can help increase pedestrian safety. Dobbs in 2009 stated in his study about pedestrian safety at Clemson University that yield-here-to-pedestrian signs with in-roadway flashing lights resulted in a 95% yield-to-pedestrian rate and in-roadway warning lights can lead to a 36% crash reduction and a 9% vehicular speed reduction. In a survey on pedestrian safety done by Sisiopiku, Akin et al. (2003), the findings were that the preferred way to cross the road was by unsignalized crosswalks midblock, of which 83% of respondents agreed with. Crosswalk location in relation to the origin and destination of the pedestrian was the most influential deciding factor (90% of respondents agreed) when a pedestrian chose a certain place to cross. Survey respondents also had a majority rule that the availability of a pedestrian crossing signal influenced the crossing location and that barriers also influenced the decision to cross.

The necessity to identify factors leading to collisions resides. A structural equation model has been developed to identify the role of environmental conditions, road characteristics, and zonal traffic behavior in Washington, D.C. Findings included that traffic signals, intersections, bus stops, and the presence of bike lanes decrease pedestrian safety. Adverse weather and areas with a high reporting of safety issues resulted in an increase in pedestrian safety (Aguilar et.al., 2018). The scenarios in this thesis experiment take place in clear daylight weather conditions, however there are different locations of the pedestrian dash out. Yannis and Golias in 2007 developed hierarchical logit models and multiple linear regressions to model pedestrian crossing behaviour along an urban trip.

Organizations such as the World Health Organization (WHO) have developed a set of objectives and plans to decrease the number of pedestrian fatalities. One measure to reduce pedestrian fatalities, as addressed by the WHO, is the development of safety-based vehicular technology. Energy absorbing bumpers are an example. A method to assess the influence of vehicular structure, which is categorized as a passive system, on pedestrian kinematics concluded that the risk from high bumper cars, such as SUV's, can be modelled. This method can be used to determine the safety of cars with kinematic criterion and biomechanical criterion considered. (Ptak, 2019). Active safety systems use sensors to avoid a pedestrian crash. A sample of 100 case study accidents involving autonomous emergency braking (AEB) were evaluated to observe the interaction between the vehicle, environment, and pedestrian. A field of view (FOV) of 35° reported the highest level of detection and reaction for crash scenarios. A system reaction time of 0.5 to 1 second was necessary (Hamdane et.al., 2015).

Vehicle design has been studied to decrease any pedestrian injury, if such an occurrence were to happen. A methodology for gathering the posture of pedestrians' pre-crash and vehicle

speeds was created using multi-body simulations and optimization techniques. The study found that there are higher sensitivities to the pedestrian's posture and the pedestrian's relative position with respect to the vehicle than the vehicles speed (Untaroiu et.al., 2009).

The environment built around people impacts how often they walk and how safe walking is. In Los Angeles, California, a five-mile segment was the study site for a complete street renovation. This segment did not provide enough data to support that complete streets embraced vision-Zero fully but found that people who live in walkable neighborhoods are less likely to be overweight and walk more often than those who do not. To support active travel, the fear of traffic danger must be surpassed. Most U.S. communities are designed to favor the vehicle user with high speeds. The goal of Complete Streets is to accommodate pedestrians and bicyclists safely as well as motor vehicles (MacLeod et. al., 2018). SmartRoads was created in Victoria, Australia about the same time that Complete Streets was created in the mid 2000's. SmartRoads has been compared to the United States Complete Streets movement for the scope and approach of the two ideas to conclude that these two frameworks can learn from each other. (Delbosc et.al., 2018)

Pedestrians may not follow the safety recommendations that advise against distraction, so the recent goal in traffic safety technology is to integrate pedestrians into the roadway communication network by allowing the smartphone to be part of the connected vehicle technology. Pedestrian to Vehicle (P2V) communication allows the driver and pedestrian to exchange their locations, even when a pedestrian is not visible to drivers due to obstacles in the sight path or the dark. There is little known about the pedestrians and drivers trust and reaction to such communications (Rahimian et.al., 2018). This thesis aims to analyze the driver's reaction to P2V warnings, especially in unpredictable pedestrian dash out scenarios.

The United States Department of Transportation (USDOT) has made vulnerable road users (VUR) safety an ongoing effort in the research of connected and automated vehicles. It is predicted that this technology will reduce nonoccupant vehicle crashes by 80%. When pedestrian cellular devices also communicate with infrastructure, there is potential for greater accuracy for pedestrian movement then solely P2V (Kevin, USDOT). The inclusive examination of these new P2V technologies is a turning point for decision makers and operators, as well as stakeholders.

2.1.4 Pedestrian Safety Surveys

When designing a survey questionnaire, it is important to develop an effective and efficient survey and include an appropriate study group. The intent of the study, importance of participation, clear questions, reasonable length, appropriate format and lack of offensiveness was included. Questions over topics such as user profile, factors that affect user crossing choices, and user perceptions about campus safety. The questionnaire was pretested to ensure that questions are adequate. Multiple influential factors could be involved in pedestrian behavior analysis, including road and traffic environmental, socioeconomic and psychological characteristics of the pedestrian and the travelling conditions (Hamed 2001). According to previous research, socioeconomic characteristics (e.g., gender, age, employment, family situation, education level, and income level of the individual) of participants may have significant impact on crossing behaviors at intersections (Haboucha, Ishaq et al. 2017). Since the population of a university community was observed, the age distribution is closely related to socioeconomic factors, such as occupation, income, and gender (Sisiopiku, Akin et al. 2003). For pedestrian safety analysis, a researcher must consider the pedestrians intention and reflect on the pedestrians interactions with their environment, including the roadway, traffic, and congestion (Yannis, Golias et al. 2007).

2.2 Pedestrian to Vehicle Communications

Pedestrian to vehicle (P2V) communication systems relay the information of nearby pedestrians through a collision prediction algorithm. The trajectory of the pedestrian is collected via broadcasting. Results that evaluated this approach showed that the system had well performance, high detection rates, and high user satisfaction (Hussein, et. al., 2016).

Many private research efforts have been done in the area of forward collision warning systems, which is a vehicle to vehicle connectivity. There are many variations on experiemental design and the study's purpose, but none accounting for the effectiveness of P2V in unpredictable scenarios. Due to the high risk of vulnerable road users, most studies have been performed using a simulation system.

2.2.1 Driving Simulator Studies

Visual warning systems use the Head-up Display (HUD). In 2006, Ho et. al., assessed the effectiveness of "intuitive" vibrotactile warning signals to prevent rear end collisions. Vibrotactile warning systems vibrate to the touch. Vibrotactile cues correctly predicted the direction of critical events in 80% of trials (Ho et.al., 2006). Another study evaluated the vibrotactile feedback for forward collision. During the experiment, the participants drive in one group of the simulator study where each group consists of three conditions of warning type. When the gap between cars is less than 40 meters, a text message on the screen is issued, asking the participant to perform a secondary task. After the secondary distraction task is performed, forward collision events were created by the software. Haptic warning alerts were activated when time to collision was less than 4 seconds (Chun et.al., 2012). In 2015, Yan et. al., conducted a study to investigate the influence of in-vehicle speech warning timing on drivers' collision avoidance performance at signalized intersections.

Pedestrian speed and location were based on previous literature. Scenario design was carefully selected in order to present pedestrian situations that have not been thoroughly evaluated before. Arterials and sudden pedestrian dash out scenarios were incorporated into the experiment. In 2016, Yu et. al.tested crash warning system effect on rear-end crash avoidance under fog conditions used the dependent variables of throttle release time, brake transition time, response time, minimum modified time to collision, and maximum brake pedal pressure .

Drivers of all ages were invited to participate in the simulation study to gather a rounded and representative study population. Over 20% of pedestrian fatalities in 2015 were over the age of 65. In order to develop preventative measures, major contributing factors to elderly crashes were defined using Empirical Bayes data mining. For a study by Das in 2019, data was collected for elderly pedestrian crashes in the United States over the years 2014 to 2016. The findings revealed an association for female pedestrians over the age of 79 with backing vehicle-related crashes, night time segment-related crashes for males of ages 65 to 69, male pedestrians ages 65 to 69 crossing an expressway at night time, failure to yield while crossing an intersection, and crashes occurring in the dark with poor street lighting (Das et.al., 2019).

Drivers and pedestrians use of mobile devices is rapidly increasing. For many years, automobile manufacturers have emphasized in-vehicle warnings and function location to assist drivers. Use of the mobile phone has become a large safety issue, especially in an urban environment with high traffic and pedestrian density. Pedestrian use mobile phones for route choices and communication. P2V technologies have been studied for wireless systems to issue warning of collision risk. Theoretical models have been performed in real world environments to test the reliability to such system. The optimal solution integrates both perception and communication systems. Another study was done on pedestrian's trust of CV technology. The

authors performed a field test with driverless, fully automated vehicles. Pedestrians were warned on their cell phones that an autonomous vehicle was approaching. The participants reported feeling as safe as they would a conventional vehicle (Hussein et. al., 2016).

Vehicle to pedestrian communication research includes a system of vehicles that can sense the environment around them and communicate to other vehicles, infrastructure and cell phones. The connected vehicle environment includes three approaches; vehicle to vehicle (V2V), vehicle to infrastructure (V2I) and vehicle to pedestrian (V2P) (Gold et.al., 2013). The USDOT is researching V2P communications for pedestrians and bicyclists, various vehicle types such as commercial vehicles, passenger vehicles, and transit, technologies that notify the driver and non-motorists, and domestic and international approaches. Pedestrian detection systems include in-vehicle systems for the drivers and handheld devices for pedestrians. In-vehicle warning systems are increasingly popular. They include blind spot warning, forward collision warning, etc. V2V communications are advancing to include intersection movement assist, lane departure assist, car following distance monitors and more. Pedestrian crash avoidance and mitigation systems are also emerging, where the vehicle would automatically brake to avoid striking a pedestrian, potentially eliminating 46 percent of pedestrian crashes. The gap in research which this study aims to fill is to quantify with certain variables exactly how much the P2V technology could reduce crash risk for pedestrians, and in more specific, how much crash reduction would occur at different locations such as the intersection and the arterial. The inclusive examination of these new P2V technologies is a turning point for decision makers and operators, as well as stakeholders.

Several applications of studies testing warning systems have been done with a driving simulation system. The warning systems can be visual, auditory, vibratory, an image or text on a screen, or a combination of the above. Multiple studies have the participant following a lead

vehicle with a designated headway at a specified speed. The unpredictable behavior and path of pedestrians calls for more studies in the future implementing P2V connectivity in different conditions and landscapes. The goal of a study by Rahman et. al., was to improve the safety of workers in work zones using P2V. All the subjects stated positive feelings for using the P2V system in this experiment. In the study, the P2V wireless communication system had two subsystems; P2I (pedestrian to infrastructure) and I2V (infrastructure to vehicle). The simulations included scenarios with and without the P2V communications, both scenarios considering lane change, deceleration, and stop distance for oncoming workers (Rahman et.al.). Despite the various usage for warning systems, there lacks a study specifically targeting the effectiveness of warning systems for pedestrian safety in unpredictable scenarios. Of special interest is the situation where a pedestrian is obstructed from view but dashes out into the roadway. This technology can also be applied to pedestrians that are not clearly marked due to nightfall, although this study was performed in daylight.

In a study on collision warning designs to mitigate driver distraction, braking events were organized in a stratified random distribution, with each scenario containing an equal number of event severity. Participants were asked to complete an auditory email task during the drive. The introductory drive consisted of a single braking event, of which the driver was told about beforehand. Only one severe braking event required a response, and it occurred at the end of the last scenario (Lee et.al., 2004).

In a study of 192 participants, there were two age groups and each participant was presented with one test drive and one FCW condition. A distraction task was presented five times during the drive and FCW was presented as an auditory warning. The conclusion was that the distraction work during the duration is applicable and represents real life scenarios. Note that while drivers

can select their own driving speed (45–65 mph), the lead vehicle was programmed to change speed such that it always maintained a headway of 2.2 s (Wu et.al., 2018). One study about pedestrian crash avoidance with warning systems noted that pedestrian speed was found to have a statistically significant influence on brake onset (Lubbe et.al., 2015). Despite various experimental design strategies, there were not many past studies that observed the reaction time to pedestrians within genders and age groups.

2.3 Conclusions

Pedestrians deaths from vehicle crashes are increasing. As more people move to urban areas, pedestrian safety must be strongly considered. College campuses are of special interest, as the drivers are novice and the pedestrian population is dense. Pedestrian behavior is influenced by many things and is often unpredictable. Suggustions for pedestrian safety include road design, such as complete streets, roadside technologies, such as rectangular rapid flashing beacons, and new in-vehicle technologies such as P2V. Pedestrians are often distracted on their cellphones while walking, which has been proven to cause distraction from the surrounding environment and to cause pedestrians to cross an intersection slower, increasing exposure to traffic. In order to integrate the pedestrian cellphone into the transportation communication stream, P2V is created. P2V is a warning system that can be portrayed via vibrotactile, auditory, or HUD visual messages. In addition, a lack of research exists comparing the findings of a collegewide survey to that of a driving simulator for P2V technologies. The comparison can bridge this gap in research for the purpose of understanding the relating factors from demographics, experience, and opinion in the survey to drivers reaction to the P2V system. Additionally, with the specific pedestrian needs of a campus identified by the campus inhabitants, solutions would be relevant and sustainable.

CHAPTER 3: UCF PEDESTRAIN SAFETY SURVEY

3.1 Background

An online survey was conducted through the web-based platform Qualtrics (www.qualtrics.com/ucf). Institutional Review Board (IRB) approval was obtained before starting the survey. The IRB approval number is SBE-18-14248. The survey can be found in Appendix A. To distribute it, multiple classes were presented with the survey asking for their participation and a table was set up in various locations on campus asking passersby to participate. We did the latter to ensure a fair participant representation of the school's population. What we resulted in was 39.3% of female and 59.8% of male survey participants (0.9% preferred not to tell gender) in comparison to UCF's 45.11% female and 54.88% male student population. The difference in gender proportions between the survey and the university are not statistically significant based on the conclusion of a Chi-squared test using SPSS (p value=0.42). The survey is representative of UCF's gender distribution. A questionnaire was created to evaluate pedestrian safety on campus. The main points included:

- Socioeconomic information of anonymous participant

- Frequency of transportation modes and traffic information modes

- Detailed questions about pedestrian and bicyclist crossing safety for specific intersections

- Rated questions for level of concern in the study area

- Campus shuttle service experience

The survey was performed from October 2018 to November of 2018. Figure 2 provides a map of the intersections that were included in the survey. A list of the intersections and road names can be found in Appendix B.

Sources: Esri, HERE, DeLorme, USGS, Intermap. INCREMENT P, NR Can, Esri Japan, METI, Esri China (Hong Kong). Esri Korea, Esri (Thailand), MapmyIndia, NGCC, ® OpenStreetMap contributor's and the GIS User Community

Figure 2: UCF Intersections Map

The number of surveys taken is 447. The number of surveys that were completed enough to have a valid weight were 343. We judged this by counting a survey if at least 50% of the questions were completed. This completion rate is 76.7%. Possible reasons for participants to not

fully complete the survey are time constraints, lack of motivation, and unwillingness to type in answers.

<div align="center">3.2 Participants</div>

A demographic depiction of the participants is shown in in Table 1. Main trends in the demographics are:

- Most of the participants (78.3% of participants) are between 19-24 years old;

- Majority of participants have the role of undergraduate student (88.7 %).

<div align="center">Table 1: Age and Gender Distribution of Participants</div>

Age Range	Gender			Total
	Male	Female	Prefer not to tell	
18-24	156	102	3	261
25-34	35	15	0	50
35-44	4	5	0	9
45-54	2	9	0	11
55-64	2	0	0	2
65-74	0	0	0	0
75-84	0	0	0	0
85+	0	0	0	0
Total	199	131	3	333

Table 1 shows the participants age range in comparison to gender. In total, 199 out of the 333 participants who answered this question were male, and 131 females. Out of the 199 male participants, 156 were in the age range of 18-24, with 35 males being in the age range of 25-34.

102 of the female participants were in the age range of 18-24 and 15 of the 131 female participants were in the age range of 25-34. There were only 2 participants in the study in the age range of 55-64.

Since the survey is designed for UCF campus, most of the survey participants were undergraduate students in the age range of 18-24. For the socioeconomic questions about the participants' role on campus and their highest level of education, 345 participants responded. The average duration of the survey was 22.88 minutes.

Legend:
- Middle School
- High School/GED
- Associates Degree
- Bachelors Degree
- Masters Degree
- Doctoral Degree
- Professional Degree
- Prefer not to tell
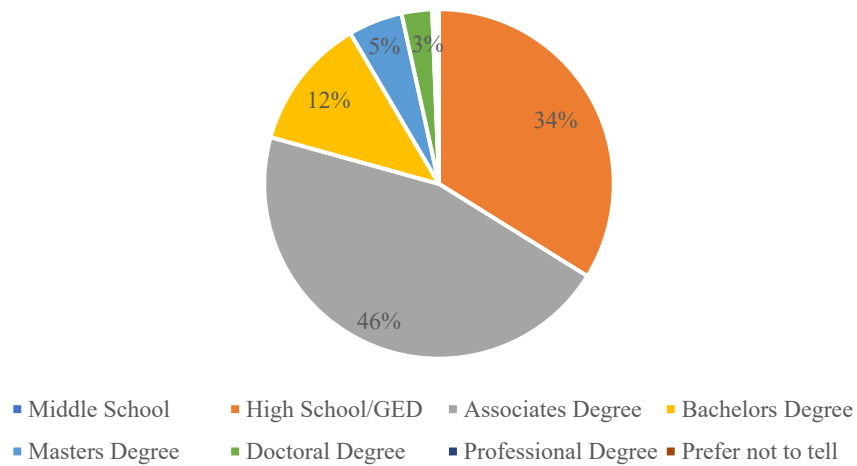
Figure 3: Highest Level of Education of Participants

Figure 3 shows that most (46.1%) of the participants are undergraduate students and 31.8% of students have a high school degree. The students who selected high school have just finished high school and most of the students who selected undergraduate degree were close to finishing or had already finished their Bachelors.
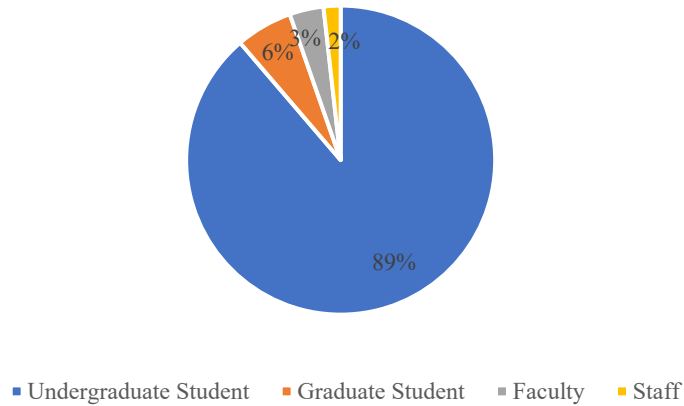
Figure 4: Participants Role on Campus

The majority (88.7%) of the population marked their role as undergraduate student. 5.9% of the participants marked graduate student and even fewer (5.2%) marked faculty and staff (Figure 4). This is representative to the UCF population via a chi-squared test (*p-value*=0.52). At UCF in 2018 the undergraduate students comprised 85.9% of the UCF population and graduate students equated to 13.3% of the UCF population. Meanwhile, Figure 5 is a summary of Figures 3 and , showing the relationship between gender and level of education.
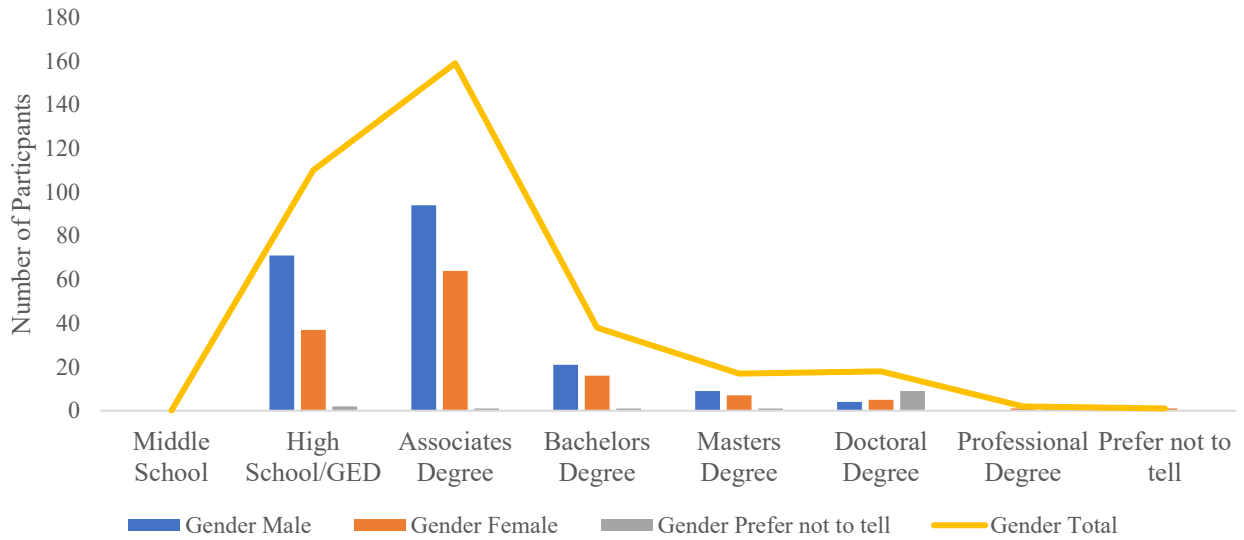
Figure 5: Gender versus Level of Education

Figure 6 shows the number of vehicles available to the survey participant. The most common answer (67.3%) was that a participant has access to one vehicle. Also, 14.3% of participants indicated that they have no access to a vehicle, who are very likely to use shuttles or walk to the campus.
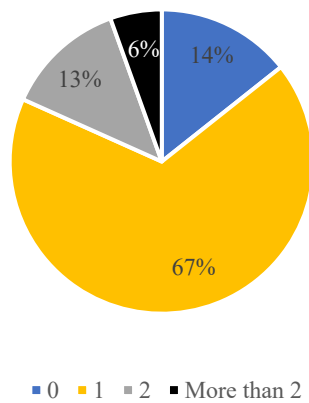
Figure 6: Number of Available Vehicles

3.3 Results

3.3.1 Transportation Information

Table 2 shows the results of traffic information reliability. Most participants (52%) agree that the traffic and travel information regarding the study area is reliable. This question involved 250 participants. The second most popular response (29.6%) was "Don't Know". This indicates that a portion of the survey population is not involved in traffic and travel information or does not know if the traffic and travel information they are receiving is accurate and reliable. Travel and traffic information can be received via radio, social media, website/smart phone app, UCF App, and UCF email or message. Students may use multiple modes to receive traffic and travel information.

Table 2**:** Reliability of Traffic Information

(Question: the traffic/travel information regarding the study area is reliable)

	Count	Percentage (%)
Strongly Agree	20	8
Agree	130	52
Don't Know	74	29.6
Disagree	21	8.4
Strongly Disagree	5	2
Total	250	100

As for the most frequent mode of transportation to and from campus, according to Table 3, the most trips taken per week were done via walking (1376 trips, or 39.5% of all participants trips), followed closely by driving a car (1336 trips or 38.3% of all participants trips). UCF's

shuttle service was used for 443 or 12.78% of trips. Several participants indicated that they had other modes to travel to and from campus which include via a skateboard or longboard and scooter.

Table 3: Number of Days per Week per Transportation Mode Descriptive Statistics

	Drive	Walk	Ride a Bike	Bus/Shuttle	Other
Mean	3.93	2.38	0.59	1.31	0.39
Median	4	0	0	0	0
Standard Deviation	4.40	3.2	2.00	2.80	2.05
Minimum	0	0	0	0	0
Maximum	50	15	20	20	26
Count	340	325	340	338	339

The mean represents the average number of days per week a participant uses a mode of transportation. The transportation mode with the highest mean was driving, with a mean of 3.93, meaning the participants drive to campus 3.93 days on average.

3.3.2 Pedestrians and Bicyclists Satisfaction

In the following section, the satisfaction of the participant was evaluated per mode of transportation. Satisfaction includes the participants survey response about safety and efficiency. The modes assessed include transit as a bicycle and pedestrian, driver, or via shuttle. The shuttle is the UCF campus shuttle that provides free transportation to campus from many off-campus housing areas. First, the satisfaction of safety and efficiency as a pedestrian or bicyclists will be detailed.

The participants were asked safety questions based on the environment of the study area as well as past experiences. Questions about pedestrian and bicyclists safety include the number of crosswalks, if drivers can easily recognize them, adequacy of bike lanes, length of signal timing, and concerns specific to pedestrians and bicyclists. The conclusion from the pedestrians and bicyclists satisfaction section based on safety is that the survey population is that the study area

itself does not need to change but that drivers do not pay attention and that it is too hot outside. Please refer to Tables 5 and 6 for the answers to the bicyclists' and pedestrians' safety questions, respectively, indicates that 50% of participants agree that there are enough locations in the study area for bicyclists and pedestrians to cross the road safely. Meanwhile, 48.7% of participants agree that the mid-blocks and intersections in the study area are safe for pedestrians and bicyclists to cross the road and that drivers can easily recognize that pedestrians and bicyclists are crossing the street. It appears that participants are pleased with the current state of pedestrian and bicycle safety in the study area in general.

Table 4: Pedestrian and Bicyclists Concerns

	Question: There are enough locations (either at the intersections or at other locations) in the study area provided for pedestrians/bicyclists to **cross** the road safely.		Question: The mid-blocks and intersections in the study area are safe for pedestrians/bicyclists to cross the road. Drivers can easily **recognize** that pedestrians/bicyclists are crossing the street.	
	Count	Percentage (%)	Count	Percentage (%)
Strongly Agree	26	7.81	20	6.09
Agree	166	49.85	160	48.78
Don't Know	76	22.82	86	26.21
Disagree	53	15.92	41	12.5
Strongly Disagree	12	3.6	21	6.4
Total	333	100	328	100

Table 5 shows that most participants (35%) do not know if there are adequate bike lanes in the study area. Since biking is the travel method used by only 5.7% of the participants (see Table 6), most participants may not be aware of the adequacy of bike lanes. Also, 26.83% of participants agree that there are adequate bike lanes in the study area. Most participants (41.64%) also indicated that they do not know if the signal timing allocated for bicyclists is enough for cyclists to cross an

intersection safely. Moreover, 39.21% of participants agree that the signal timing is long enough for bicyclists to cross an intersection safely.

Table 5: Bike Safety

	Question: There are adequate bike lanes for bicyclists to ride bikes in the study area.		Question: The signal timing allocated for bicyclists is enough for cyclists to cross an intersection safely.	
	Count	Percentage (%)	Count	Percentage (%)
Strongly Agree	20	6.09	36	10.94
Agree	88	26.83	129	39.21
Don't Know	116	35.37	137	41.64
Disagree	67	20.43	16	4.86
Strongly Disagree	37	11.28	11	3.34
Total	328	100	329	100

Table 6 shows that most (54%) participants agree that the signal timing allocated is enough for pedestrians to cross an intersection safely, as 15.76% of participants strongly agree with this question as well.

Table 6: Pedestrian Safety

	Question: The signal timing allocated for pedestrians is enough for pedestrians to cross an intersection safely.	
	Count	Percentage (%)
Strongly Agree	52	15.76
Agree	179	54.24
Don't Know	40	12.12
Disagree	48	14.55
Strongly Disagree	11	3.33
Total	330	100

As for the efficiency aspect of the pedestrian and bicyclists' satisfaction, the bicyclists were asked if there are enough bike parking and racks in the study area, if there are enough bike lanes, and the pedestrians were asked if there are enough sidewalks. The conclusion is that there are no

major concerns about the pedestrian and bicyclists' efficiency of the study area, and therefore the participants are overall satisfied in this topic.

The survey included 6 questions about bicycle safety topics that the participant was to rank on level of agreement from 1 to 5, with 1 being of the least concern and 5 being the most concerning, meaning this topic is one that the participant strongly agrees needs to be evaluated. The average number of participants that answered each these six questions was 318 participants. 28.3% of participants chose a score of 1, which was the most chosen answer for all six questions. This means most of the participants had little concern with any of the topics listed for bicycle safety in the study area. Only 10.6% of the responses indicated a concern of level 5. The level five concern responses were mostly for the questions "It is too hot to ride a bike" with 31% of level five concerns being for this question and "Drivers do not yield for bicyclists" with 23% of level five concerns being for this question (Figure 7).
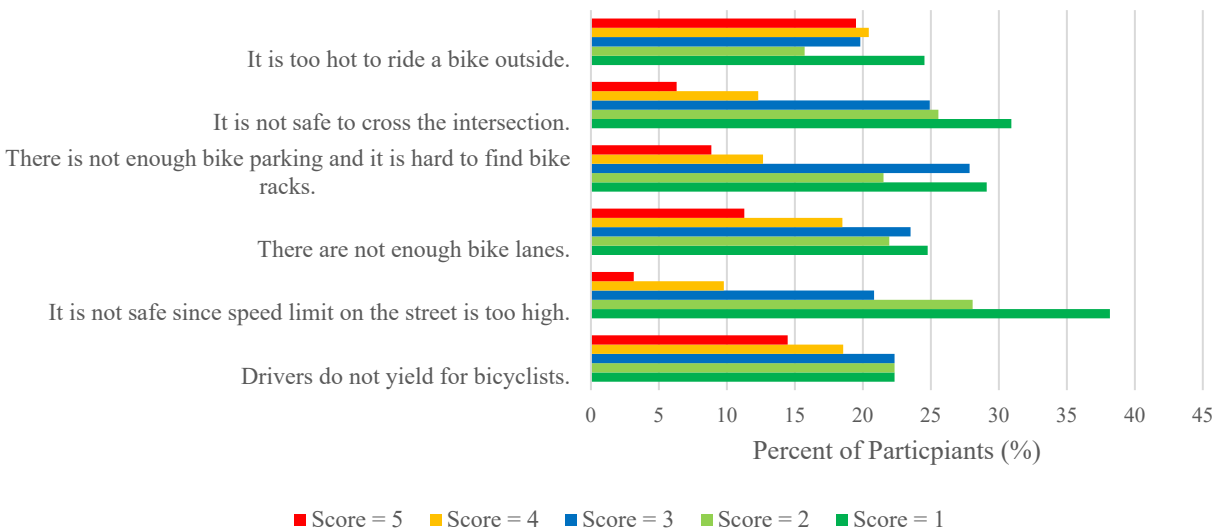
Figure 7: Bicycle Concerns

The survey included 6 questions about pedestrian safety topics that the participant was to rank on level of agreement from 1 to 5, with 1 being of the least concern and 5 being the most

concerning, meaning this topic is one that the participant strongly agrees needs to be evaluated. The average number of participants that answered each these six questions was 322 participants. Meanwhile, 31.4% of participants chose a score of 1, which was the most chosen answer for all six questions. This means most of the participants had little concern with any of the topics listed for bicycle safety in the study area. Only 13.8% of the responses indicated a concern of level 5. The level five concern responses were mostly for the questions "It is too hot to walk outside" with 51% of level five concerns being for this question and "Drivers do not yield for pedestrians" with 23% of level five concerns being for this question (Figure 8).
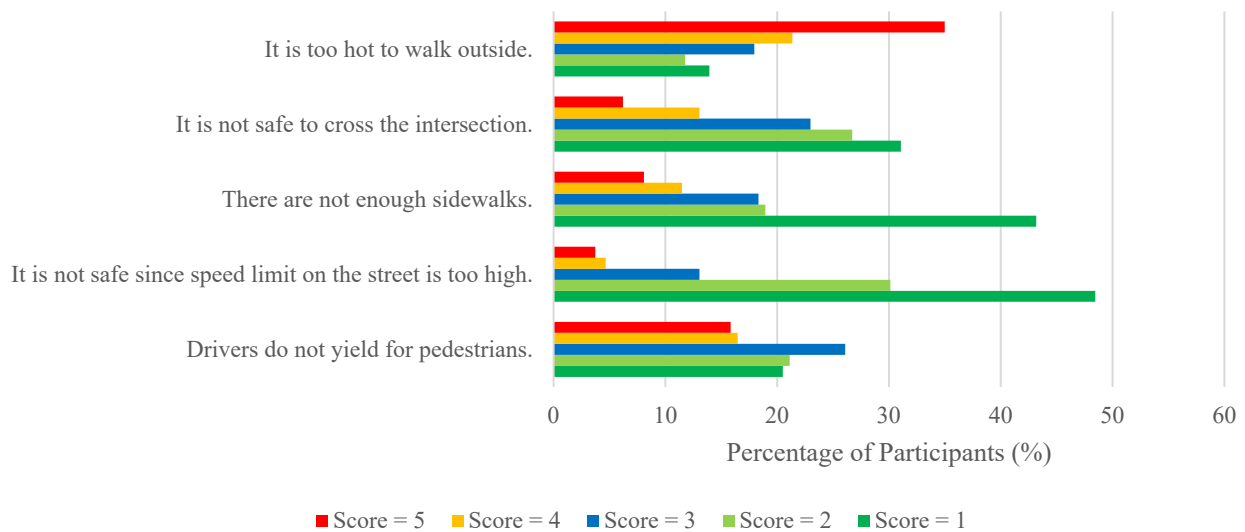
Figure 8: Pedestrian Concerns

3.3.3 Drivers' Satisfaction

Satisfaction of the safety as a driver relates directly to the satisfaction of the pedestrian. The driver must be safe in the study area and easily be able to see pedestrians. The participants were asked about the driver's environment and past experiences in the study area. The conclusion is that the drivers' level of safety satisfaction in the study area is safe. The participants agree that

the midblock and intersections are safe for pedestrians to cross the road. Meanwhile, 68% of participants marked that they have never hit or almost hit a pedestrian while driving in the study area.

Table 7 shows that most participants (48.62%) agree that the mid-blocks and intersections in the study are safe for pedestrians and bicyclists to cross the road and that drivers can easily recognize that pedestrians and bicyclists are crossing the street. Also, 26.29% of participants chose the answer "Don't Know" for this question. Perhaps those that chose "Don't Know" are the participants who take the shuttle or do not drive, and do not observe such occurrences.

Table 7: Drivers' Concern

| | Question: The mid-blocks and intersections in the study area are safe for pedestrians/bicyclists to cross the road. Drivers can easily recognize that pedestrians/bicyclists are crossing the street. | |
	Count	Percentage (%)
Strongly Agree	20	6.11
Agree	159	48.62
Don't Know	86	26.29
Disagree	41	12.54
Strongly Disagree	21	6.42
Total	330	100.00

Table 8 shows that most participants (68.24%) did not ever encounter any situation in which they have hit or nearly hit a pedestrian or bicyclist while driving. Out of those who chose no for this question, 61.88% were male and 38.11% were female.

Table 8: Drivers Encounter with Pedestrians and Bicyclists

| | | Question: Did you ever encounter any situation that you have hit or nearly hit a pedestrian or bicyclist while driving? | |
		Count	Percentage (%)
Yes	Female	34	11.49
	Male	60	20.27
No	Female	77	26.02
	Male	125	42.23
Total		296	100.00

In the survey a map of the UCF intersections was included, and participants were asked to identify which intersection best fit the questions description. The results show that intersections 5, 11, 12, 13, 16 and 17 are intersections of the most concern (Figure 9). Intersection 5 is the crossing of University Boulevard and Alafaya Trail. Both streets are considered highways and have very heavy traffic. There is a popular apartment complex and retail area on this intersection, as well as the entrance to UCF campus. Intersection 11 and 12 are the crossings of Gemini Boulevard and the CFE Arena. Many students on campus cross these two intersections to enter the CFE arena, study rooms, the gym at the plaza, the dormitories on this side of campus, and the food plaza. Intersections 11 and 12 are used daily by many students driving and walking on campus. Intersection 13 is the crossing of Gemini and Orion, a road that passes the football stadium and softball fields from McCulloch Boulevard to campus. It is important to note that intersection 13, leading to garage D, only has a pedestrian crosswalk on the left side of the intersection crossing Gemini Blvd. Intersection 13 leads directly to parking garage D on campus and is commonly used to approach garage C as well. Intersection 16 is the crossing of Gemini and Libra. Intersection 16 is commonly used to enter or exit campus towards research parkway with many office buildings and the entrance to highway 408. Intersection 16 was the intersection with the most participants concern with 51 participants showing concern. The second most concerning intersection (49 participants expressed concern) was the intersection in front of the UCF gym, intersection 17. Intersection 17 leads to parking garage B and is very heavily traveled as students use this intersection to approach the gym, dormitory's or cross over to the heart of campus.

Sources: Esri, HERE, DeLorme, USGS, Intermap. INCREMENT P, NR Can, Esri Japan, METI, Esri China (Hong Kong). Esri Korea, Esri (Thailand), MapmyIndia, NGCC, ® OpenStreetMap contributor's and the GIS User Community

Figure 9: Map of Intersections of Concern

3.3.4 Campus Shuttle Service Satisfaction

The safety of the shuttle service is vitally important to passengers in the shuttle and drivers sharing the road with the shuttle. For the sake of the reputation of the university and Redcoach bus services, the safety and efficiency of the shuttle system are vital. There were no questions about the safety of the shuttle system.

The efficiency of the shuttle system was evaluated through questions about the shuttles schedules and the participant's experiences using the shuttle. Slightly over half (50.6%) of the participants use the shuttle service. Of those who do, 39.29% agree a little that they are very satisfied with the shuttle schedule. 54.95% of participants who use the shuttle live within 3 minutes walking to their shuttle stop. Only 8.97% of participants agree strongly that the shuttle arrives on time always. The two most common reasons that participants use the shuttle is to save money and time.

As we can see from Table 9, for the question "Do you use the UCF shuttle service?" most of the participants responded no (57.5%) and of those who responded no most were male (63%). For the question "Is your place of residence served by the UCF shuttle service?" most respondents said yes (50.6%) and out of those who said yes it was an even proportion of genders. What we can gather from these questions is that most participants had access to the shuttle service, but most participants chose not to use the shuttle. As we mentioned previously, most participants walk or drive a car to campus. Only 12.7% of participants indicated riding the shuttle to campus and back.

Table 9: Shuttle Service and Gender

		Do you use the UCF shuttle service?	Is your place of residence served by UCF shuttle service?	My place of residence is the first/last stop of the UCF shuttle route.
Yes	Female	56	45	22
	Male	77	44	28
	Subtotal	133	89	50
No	Female	66	46	24
	Male	114	41	21
	Subtotal	180	87	45
	Total	313	176	95

Table 10 answers the question "I am very satisfied with the UCF shuttle schedule". Most (39.29%) of participants agree a little with this question. Out of those who agree a little, 27.38%

were male and 11.9% female. The second most popular choice was that the participant agreed strongly with the question, of which 23.81% of the participants chose. 10.71% of participants disagreed strongly with the question, of which 5.95% were female and 4.76% were male.

Table 10: Shuttle Schedule Level of Satisfaction

		Count	Percentage (%)
Agree Strongly	Female	9	10.71
	Male	11	13.10
Agree a little	Female	10	11.90
	Male	23	27.38
Neither Agree nor Disagree	Female	3	3.57
	Male	1	1.19
Disagree a little	Female	8	9.52
	Male	10	11.90
Disagree Strongly	Female	5	5.95
	Male	4	4.76

Figure 10 shows the time in minutes that the participant must walk to reach the nearest shuttle stop. As it is shown in Figure 10, 54.95% of participants must walk within 3 minutes to reach their shuttle stop. This is an indicator that the shuttle stops are in efficient locations. The second largest selection was that 16.48% of participants must walk for 6-10 minutes to reach their shuttle stop. The majority of the participants have a short walk time to reach the shuttle stop, confirming that the shuttle stops are at efficient and convenient locations.
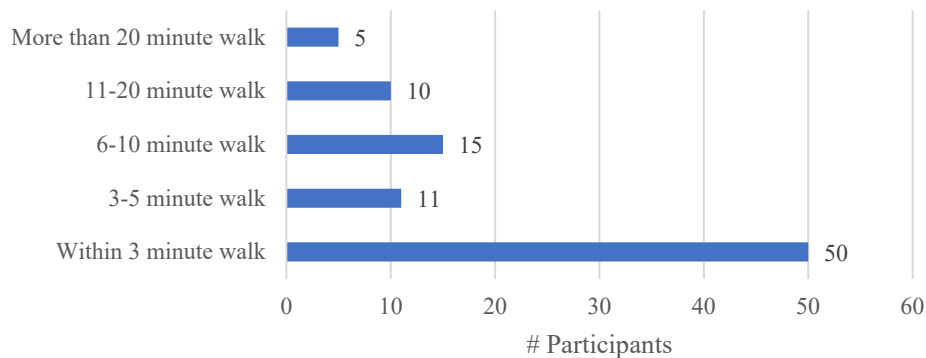
Figure 10: Length (Minutes) to Walk to Shuttle Stop

Table 11 displays the answers to the question if the shuttle always arrives on time. Thirty-three percent of the participants say that they agree a little that the shuttle always arrives on time. Out of those who agree a little that the shuttle always arrives on time, 20.51% are male and 12.82% are female. Few (8.97%) of participants marked that they strongly agree and 23.08% of participants marked that they strongly disagree with the question. This is a question that shows that the efficiency of the shuttle service could be improved by meeting more accurate arrival times.

Table 11: Shuttle Arrival Time Level of Satisfaction

		Count	Percentage (%)
Agree Strongly	Female	4	5.13
	Male	3	3.85
Agree a little	Female	10	12.82
	Male	16	20.51
Neither Agree nor Disagree	Female	4	5.13
	Male	0	0.00
Disagree a little	Female	6	7.69
	Male	17	21.79
Disagree Strongly	Female	9	11.54
	Male	9	11.54

Figure 11 displays the answers to the survey question asking participants why they use the shuttle service. The most popular answer (36.92% of participants) was to save money. The second

most popular answer (32.31% or participants) was to save time. This may be an indicator to the parking situation or traffic in the study area. Meanwhile, 24.6% of participants that were included in this question use the shuttle because they do not own a car. Seeing how there are 75.38% of participants who answered this question that do own cars and choose to take the shuttle indicates that the shuttle is more efficient for these participants, and they are more satisfied with the shuttle then to drive themselves.

■ Save money ■ Save time ■ Environmentally friendly ■ Do not own a vehicle
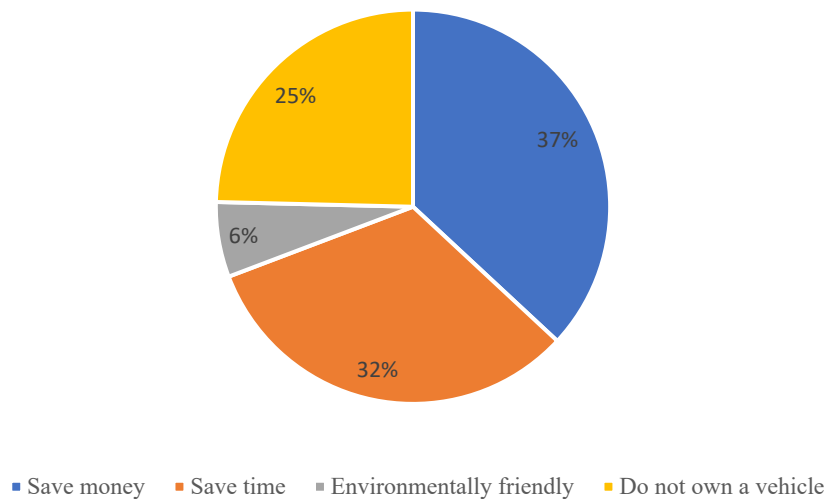
Figure 11: Why Participants use the Shuttle System

3.4 Conclusions

Satisfaction in the areas of safety and efficiency were evaluated for pedestrians and bicyclists, drivers, and those who use the shuttle system. The pedestrian and bicyclists concluded that safety is satisfactory, but drivers do not pay attention to pedestrians. Moreover, the hot weather is a serious concern for pedestrians and cyclists. As for efficiency for pedestrians and bicyclists in the study area, there were no concerns. The driver's level of satisfaction indicated that the safety of the driver is not in concern and 68% of drivers marked that they have never hit or almost hit a pedestrian or bicyclists in the study area. The study also found that satisfaction for the efficiency

of the shuttle system was met but not strongly, since 39.29% of participants agree a little that the shuttle system has a satisfactory schedule. The most common reasons to use the shuttle are to save money and time. Finally, intersections of concern include intersections at the most commonly used parking garages, intersections on campus where pedestrian activity is high leading to dorms and campus facilities, and the gym. The intersection of University and Aloma was also a concern to participants. These intersections of concern are heavily populated and lead to major areas on campus, such as dorms, the gym, or one of the most popular parking garages. Unfortunately, these intersections are where the most UCF Police reports have been filed for car crashes and pedestrian crashes (cite). These intersections all have crosswalks connecting at least 3 legs of the intersection. In January of 2018 UCF Police Department installed "STOP for Pedestrian in Crosswalk" signage at five locations across campus and five crosswalks with flashing yellow lights. Law enforcement has also increased with greater attention to driver's on campus who do not yield to pedestrians. In the near future, Orange County and the State of Florida have invested near $9 million in pedestrian facility improvements around campus, including pedestrian fencing and landscaping, a wide bike path/pedestrian trail along Alafaya Trail, colored mid-block cross walks, lighting, and more (Schuleb, 2018).

CHAPTER 4: P2V DRIVING SIMULATOR STUDY

4.1 Background

In order to address the gap in research pertaining to the effectiveness of P2V warning systems, especially in unpredictable situations, the research team has created a simulation of random pedestrian crash scenarios. The research team has tested the scenarios with and without a warning system to ensure that the warning system is useful and provides high quality impacts, such as decreasing drivers' reaction time and increasing drivers' reaction quality when avoiding a pedestrian crash. Participants were recruited for all ages and genders. The paired T-test analysis was used to evaluate the safety benefits and driving behaviors under the connected-vehicle environment. Participants' behavior and other related variables were collected during the experiments.

4.2 Participants

Forty seven participants were recruited for this study. Participants gender and age proportion were balanced. The average age of the participant was 32 years old, ranging from 18 to 81 years old. Each participant had a valid driver's license and at least 1 year of driving experience. The experiment lasted for about an hour in total for each participant. The study aimed to have a participant population representative of the driving population currently on the roads. Institutional Review Board (IRB) approval was obtained before starting the experiments. The IRB approval number is SBE-18-13983.

When participants arrived in the laboratory, they were first shown a document with the IRB regulations and qualifications and an introduction of the experiment. All participants were required to read a consent form before the experiment and to fill out two forms regarding their demographics and driving background, as seen in Appendix C and D. Participants were told that

if at any time during the experiment there was a feeling of motion sickness, the participant could take a break or quit the experiment. Before the formal experiment, a video was shown to participants on how to drive the simulator and certain requirements for the scenarios. Then, participants were given a 10-minute trial scenario to become familiar and trained on the operation of the driving simulator. Next, the participant performed the formal driving experiment which had pedestrian crash scenarios with and without warnings. Between each trial, participants were offered time to rest and water. After the experiment, participants were asked to fill out a form about their experience and how effective they deem this technology, as seen in Appendix E.

4.3 Apparatus

The National Advanced Driving Simulator (NADS MiniSim) was the simulator used for this experiment. The simulator is located on The University of Central Florida campus. NADS MiniSim provides a 130° horizontal by a 24° vertical field of view via three screens, each of which were 22.5" high and 40.1" wide. The participants sat in front of the screens in a seat similar to a car, which could be adjusted with a lever under the front of the seat and a knob at the seats hinge to lean back or forward. Two speakers were installed in the front of the driver to mimic the sound of the passenger car (such as noises from the brake or wheel when turning or braking) and auditory warning messages. A third speaker was mounted below the driver's seat to mimic roadway vibrations. Messages appeared on the screen through a HUD interface directing the participants to turn or drive in specific lanes, as shown in Figure 12. Text warning messages about pedestrians' presence or a forward collision warning were presented at the bottom of a screen through a HUD interface. The simulator was equipped with a four-channel video capturing system, and collected data at a rate of 60 Hz.

Figure 12. NADS MiniSIM driving simulator with HUD interface

4.4 Experimental Design

Narratives in crash reports from the Signal Four Analytics were analyzed. This study identified the causation of the pedestrian-related crash by using the Driving Reliability and Error Analysis Method (DREAM) from these crash reports. The scenarios of pedestrian crashes were then established based on the summarized crash causation. Next, the study used the driving simulator to test the driver responses to the P2V technology at the intersection and the arterial. The experiment was designed as a within-subject experiment with the combination factors of 2*2 (i.e.,

pedestrian behavior types , warning types). Also, the scenarios without warning were used as the base conditions.

Forty seven (47) participants drove in 2 scenarios in an order that was randomly assigned to each of the participants. Each scenario took around 10 minutes. The scenario order was randomly assigned to the participant in order to avoid the order effect, where participants may behave differently in the later scenarios due to tiredness, motinsickness, or prediction of the crash scenarios. In the 2 scenarios, critical events were unpredictable. Each scenario contained two critical events. Each scenario contained two blocks, one block without the P2V connectivity warning and one block with P2V connectivity warning. First, the participant drove the scenario block without any warning, and then with the warning. Each block included one pedestrian crash scenario. The locations of the pedestrian crashes were randomly assigned out of eight locations. For this experiment, an auditory and icon P2V warning system was implemented.

Table 12: Experimental Design Conditions and Scenarios

Scenario ID	Location	Weather Condition	Details
S1	Road Segment	Daylight, clear	No marked crosswalk, driver is driving through at 45 mph, pedestrian is obstructed from view. Suddenly, the pedestrian dashes out to across the road.
S2	Road Segment	Daylight, clear	No marked crosswalk, driver is driving through at 45 mph, pedestrian is at the roadside in view. Suddenly, the pedestrian dashes out to across the road.

4.5 Experimental Results

Five critical measurements were defined and extracted to evaluate the participants driving performance. The measures include (1) number of collisions, (2) mean deceleration, (3) maximum deceleration, (4) BTMB, and (5) minimum distance. These measurements are explained as follows:

(1) Number of Collisions;

Number of collisions are the number of times a driver experienced a pedestrian crash.

(2) Mean Deceleration;

Mean deceleration is measured from the beginning of deceleration to the time of minimum distance (if the participant did not stop) or stopping distance. Mean deceleration is measured in meters per second squared.

(3) Maximum Deceleration;

Maximum deceleration is measured in meters per second squared.

(4) BTMB;

Brake to maximum brake time in seconds.

(5) Minimum Distance;

Minimum distance is the distance from the car to the pedestrian when the pedestrian is approaching the road.

Forty-seven valid samples were collected for the scenario S1 and scenario S2. The statistical significance level was set to be alpha = 0.05

4.5.1 Number of Collisions
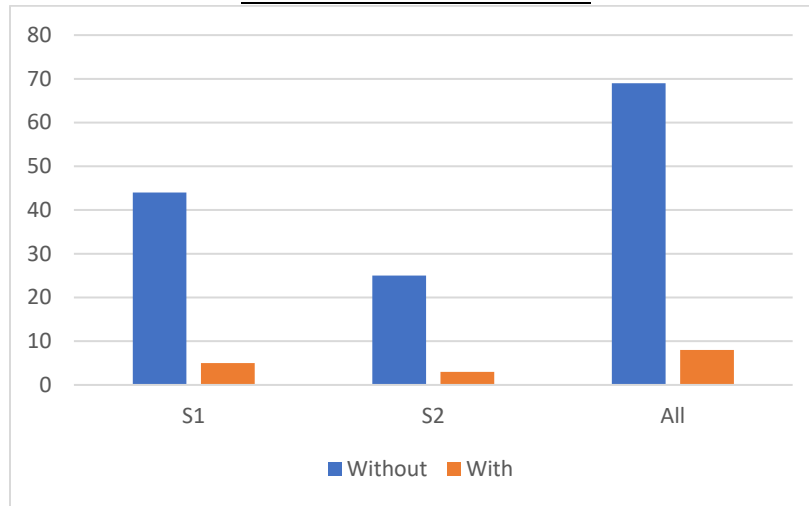
Figure 13: Number of Collision Events

The P2V warning system reduced the amount of crashes in both scenarios. Figure 13 shows the number of collision events in different scenarios. In scenario S1, in which the pedestrian was obstructed from view, the crash reduced by 88.6% after applying the warning system. In scenario S2, in which the pedestrian was observable, the crash reduced by 88%. The total reduction rate in crashes for both scenarios is 88.4%.

4.5.2 Mean Deceleration

Figure 14 shows the distribution of the mean deceleration in different situations. In scenario S1, when there was no P2V warning, the driver's mean deceleration was 2.76 m/s^2 on average. When there was the P2V warning, the average mean deceleration increased to 6.75 m/s^2.

In scenario S2, the average driver's mean deceleration was 0.95 m/s^2 when there was no P2V warning and 2.64 m/s^2 with the warning. The paired t-test shows that the difference of the brake reaction time between with and without the P2V warning is significant (P-value<0.0001).
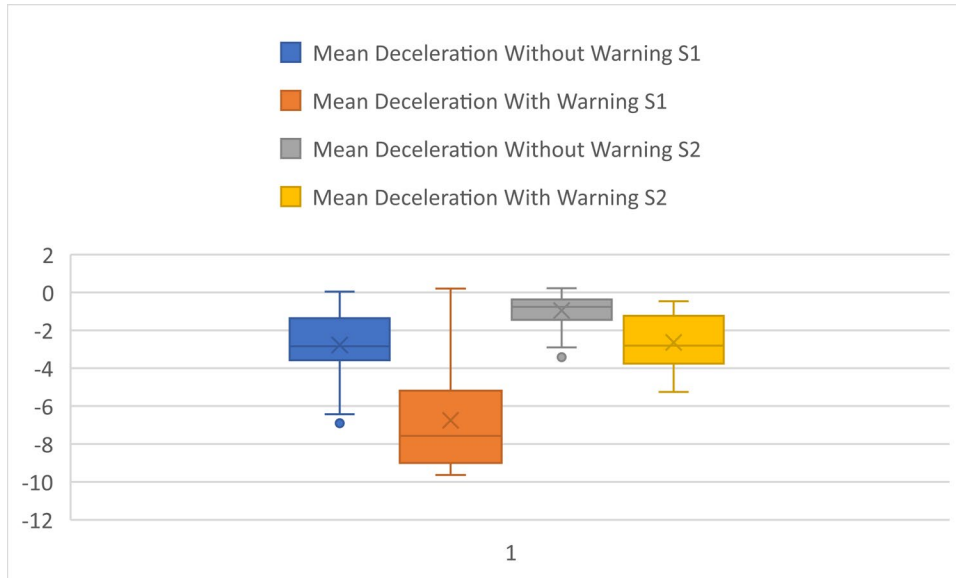
Figure 14: Brake Reaction Time

4.5.3 BTMB

In the scenario S2, the average BTMB was 2.63 seconds in the cases which have no warning and the average BTMB reduced to 1.30 seconds when the warning was given to the driver. Considering both scenarios, the BTMB reduced from 1.34 seconds to 0.77 seconds, a 42.5% decrease, as shown in Figure 15.
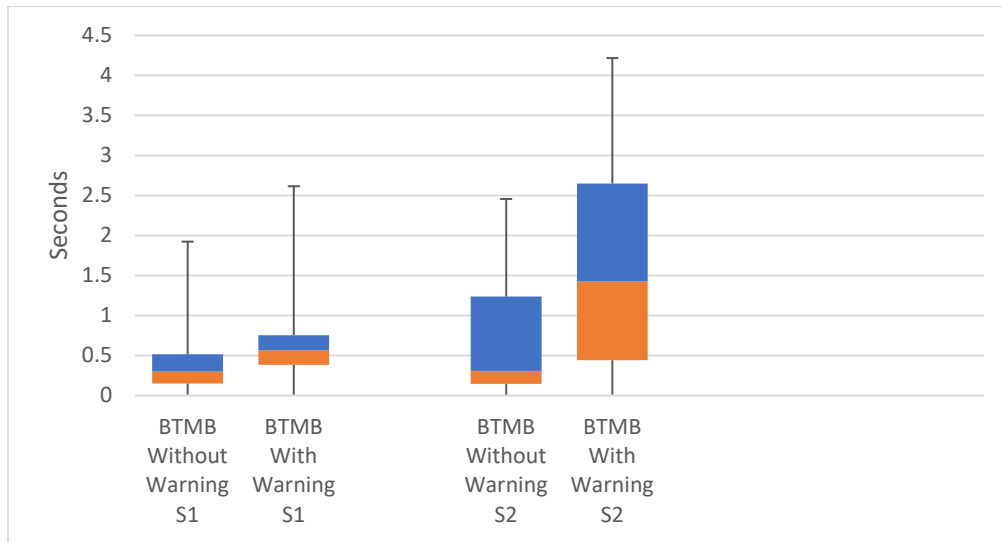
Figure 15: Impact Velocity

In S1, the average maximum deceleration was 8.53 m/s2 without the warning and 9.64 m/s2 with the warning. In S2 the maximum deceleration was 5.76 m/s2 without the warning and 7.47 with the warning. Considering both scenarios, the maximum deceleration increased 20% with the presence of the warning.

4.5.5 Minimum Distance

Figure 16 shows the minimum distance distribution for both scenarios. The minimum distance increases from an average of 0.72 meters without the warning to an average of 8.36 meters with the warning for S1. For S2, the minimum distance averages 3.44 meters without the warning and 7.05 meters with the warning.
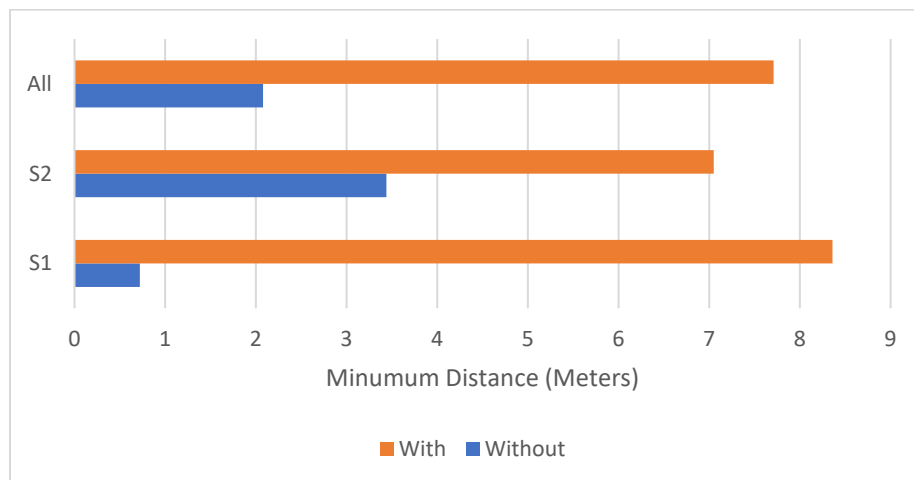
Figure 16: Minimum Distance

4.6 Conclusions

As a within-subject experiment, each participant is tested under all conditions. The advantage of within-subject experiments is that there is maximum control of extraneous participant variables. It is expected that a within-subject experiment results in data that is less noisy. The negative effect of a within-subject experiment is the carryover effect, where a participant may perform a task better in later conditions due to practice, or the participant may

become tired or bored. The carryover effect was avoided because the pedestrian location and timing was random for each scenario. This way, the participant could not remember where the pedestrian crossed beforehand and expect the same.

In both scenarios, the P2V warning system successfully reduced the number of crash events by 88%. The P2V warning reduced more crashes in the pre-crash scenario in which the pedestrian was obstructed from the view than in the pre-crash scenario in which the pedestrian was observable. This indicates that the P2V warning system may be more effective in those unpredictable pre-crash scenarios by providing warning information to the driver.

The average increase in maximum deceleration with the presence of the warning system is 20%. The maximum deceleration increase for S2 was greater than for S1. Mean deceleration also increased with the presence of the warning system for both scenarios. Mean deceleration was larger for S1 than S2.

The paired t-test shows that the difference of the brake to maximum brake reaction time between with and without the P2V warning is significant. This indicates that the warning system could make drivers more alert. In scenario S1 the pedestrian was obstructed from the view before the pedestrian dashed out thus a driver tended to be more alert when he or she recieved the warning. The driver became more cautious and expected the presence of the pedestrian. However, in scenario S2 the pedestrian was observable before the crash and a driver may think he or she would be able to handle a sudden crash risk, thus less participants decided to keep the foot on the brake. Because of the above reasons, the average brake to maximum brake reaction time in the scenario S1 is less than that in the scenario S2.

Minimum distance from the stopping point of the driver to the pedestrian increased significantly with the presence of the warning system. The average increase in minimum distance

with the execution of the warning system is larger for S1 than S2, and increases for both scenarios. In S1 the pedestrian is hidden from view, so the driver stops upon immediately recieveing the warning, unkowing where the pedestrian will cross, in comparison to in S2 the driver knows where to stop because they can see the pedestrian, and end up stopping closer to the pedestrian.

CHAPTER 5: MODELS TO IDENTIFY PEDESTRIAN SAFETY ISSUES

5.1 Background

5.1.1 Abstract

This section of the thesis presents a safety analysis of pedestrians and bicyclists from the perspective of college campus students and employees who use various forms of transportation (e.g. walk, driving, cyclists). The paper utilizes data collected from a web-based survey that was distributed to around four hundred University of Central Florida (UCF) campus students, faculty, and staff. Two pedestrian safety evaluation models (pedestrian/cyclists point of view and driver's point of view) were estimated using univariate probit modeling based on data collected from the survey. The objective of the models was to determine the level of pedestrian and bicyclist safety around campus from the pedestrians' perspective and drivers' perspective, and to identify the factors that contribute to safety. The results emphasized that participants who have experienced unsafe situations in the study area as a pedestrian walk and bike often, agree that drivers' do not yield for pedestrians, agree that it is not safe to cross the intersections in the study area, and agree that there are enough locations to cross. The participants indicated that there is a higher chance of having hit or nearly hit a pedestrian while driving if they drive more often and agree that all drivers on the road do not yield for pedestrians.

5.1.2 Introduction

Pedestrian deaths accounted for 16% of motor vehicle crash fatalities in 2016 (National Highway Traffic Safety Administration, 2016).

College campuses are made up of a dense population of drivers and pedestrians with different levels of familiarity with the area and experience. Identifying key safety issues from the perspective of the pedestrians and bicyclists can help know what needs to be improved.

College campuses pose a specific traffic and pedestrian dense environment. There are thousands of vehicles entering campus every day. Moreover, several traffic peaks could exist related to class schedule instead of the typical commute traffic that has two peaks (i.e. morning peak, afternoon peak). Meanwhile, since students may need to take multiple classes in one day at different class building, heavy pedestrian volume may present during break time. By decreasing the congestion around campus, the hope is that traffic crashes will also be reduced due to less cars on the streets, which may also decrease the potential conflicts with pedestrians and cyclists.

Xie and Verplaetse in their 2019 study conclude that intersections with higher signage and pedestrian signals have better pedestrian safety than intersections with solely crosswalks and no pedestrians' signals.

Despite previous pedestrian safety studies, few have compared the perspective or drivers to pedestrians for campus areas in specific. Based on survey data, two logistic regression models were employed to conduct the analysis in this study. Logistic regression explains the relationship between explanatory variables and a binary variable, which is if they have experience of unsafe situations between pedestrians/cyclists and vehicles from both pedestrian/cyclist point of view and driver point of view in the UCF campus and the adjacent intersections.

5.2.1 Survey Design

Multiple influential factors could be involved in pedestrian behavior analysis, including road and traffic environment, socioeconomic and psychological characteristics (Hamed 2001). According to previous research, socioeconomic characteristics (e.g., gender, age, employment, family situation, education level, and income level of the individual) of participants may have significant impact on crossing behaviors at intersections (Haboucha et al. 2017). Since the population of a university community was observed, the age distribution is closely related to socioeconomic factors, such as occupation, income, and gender (Sisiopiku et. al., 2003). For pedestrian safety analysis, a researcher must consider the pedestrians intention and reflect on the pedestrians interactions with their environment, including the roadway, traffic, and congestion (Yannis et. al., 2007).

The univariate probit models each have one dependent binomial variable, if the participant has experienced an unsafe situation as a pedestrian and if the participant has hit or nearly hit a pedestrian while driving. The distribution for the dependent variables are shown in Table 13.

Table 13: Distributions of Dependent Variables

Dependent Variable	Frequency	Percentage
Participant has experienced unsafe situations as a pedestrian in the study area.		
Yes	157	49.53%
No	160	50.47%
Participant has hit or nearly hit a pedestrian in the study area.		
Yes	226	67.66%
No	108	32.34%

The survey consisted of 362 observations for 62 variables, 40 of which were used for modeling purposes. The variables are shown in Table 14:

Variable	Mean	Standard Deviation
How many times a week do you use the following transportation modes when you travel to and within the study area? - Drive a car	3.880	4.313
How many times a week do you use the following transportation modes when you travel to and within the study area? - Walk	3.913	10.971
How many times a week do you use the following transportation modes when you travel to and within the study area? - Ride a bike	0.561	1.948
How many times a week do you use the following transportation modes when you travel to and within the study area? - Take a bus/shuttle	1.256	2.739
How often do you do carpool to campus/back to home?	3.766	1.319
The traffic/travel information regarding the study area is reliable.	3.573	0.840
The sig l timing allocated for pedestrians is enough for pedestrians to cross an intersection safely.	3.633	1.014
Drivers do not yield for pedestrians.	2.874	1.341
It is not safe since speed limit on the street is too high.	1.838	1.043
There are not enough sidewalks.	2.176	1.310
It is not safe to cross the intersection.	2.356	1.213
It is too hot to walk outside.	3.513	1.432
There are adequate bike lanes for bicyclists to ride bikes in the study area.	2.925	1.083
The signal timing allocated for bicyclists is enough for cyclists to cross an intersection safely.	3.501	0.877
Drivers do not yield for bicyclists.	2.810	1.350
It is not safe since speed limit on the street is too high.	2.098	1.123
There are not enough bike lanes.	2.725	1.343
There is not enough bike parking and it is hard to find bike racks.	2.490	1.279
It is not safe to cross the intersection.	2.375	1.226
It is too hot to ride a bike outside.	2.950	1.474
Did you ever encounter any unsafe situation in the study area as a pedestrian or bicyclist?	1.660	0.666

Variable	Mean	Standard Deviation
There are enough locations (either at the intersections or at other locations) in the study area provided for pedestrians/bicyclists to cross the road safely.	3.411	0.972
Did you ever encounter any situation that you have hit or nearly hit a pedestrian or bicyclist while driving?	1.755	0.551
Suppose you are driving to cross an intersection (make a turn or drive through). At this time you have noticed a pedestrian/bicyclist is still on the crosswalk. How often have you experienced this situation?	2.132	0.965
The mid-blocks and intersections in the study area are safe for pedestrians/bicyclists to cross the road. Drivers can easily recognize that pedestrians/bicyclists are crossing the street.	3.362	0.981
Do you use the UCF shuttle service?	1.592	0.492
How do you usually obtain UCF shuttle information? - Selected Choice	4.187	1.043
Shuttle takes longer then other modes	1.261	0.8453
Is your place of residence served by UCF shuttle service?	1.699	0.587
I am very satisfied with the UCF shuttle schedule.	3.473	1.292
What is the distance between your place of residence and the closest UCF shuttle schedule?	1.978	1.278
The shuttles always arrive on time.	2.783	1.326
My place of residence is the first/last stop of the UCF shuttle route.	1.330	0.612
Do you live on the UCF campus?	1.990	0.199
Average distance to campus from home zipcode	16.623	30.559
Which of the following ranges best describes your age?	1.335	0.770
What is your gender?	1.411	0.510
Which is the highest level of education you have completed?	2.986	0.990
Which is the best description of your role on campus - Selected Choice	1.272	0.806
How many cars are available to you?	2.099	0.691

5.2.2 Univariate Probit Models

The univariate probit model is used to model the probability of an observation falling into one of two outcomes. The univariate model has p progressors, with β coefficients. $\emptyset(\beta_0 + \beta_1 x_1 + \cdots + \beta_p x_p)$ is the cumulative standard normal distribution and π is the probability of the outcome. (Alsoruji, 2018). The univariate probit model is defined in the following equation.

$$\pi_1 = \emptyset(\beta_0 + \beta_1 x_1 + \cdots + \beta_p x_p)$$

$$\pi_2 = \emptyset(\beta_0 + \beta_1 x_1 + \cdots + \beta_p x_p)$$

π_1 and π_2 are the dependent variables that represent if the participant has experienced an unsafe situation as a pedestrian and if the participant has hit or nearly hit a pedestrian while driving. The model is formulated using SAS PROC QLIM. The univariate models are evaluated using goodness-of-fit measures and the significance of predictor variables (Lee, 2017).

5.3 Results

5.3.1 Modeling Results

In total, 8 variables are employed in this study as independent variables (Table 15). Two univariate probit models were built in order to analyze pedestrian safety issues from pedestrians and drivers' point of view.

Table 15: Independent Variables Descriptive Statistics

Quantitative Variables	Variable Name	Number of Participants	Mean	Standard Deviations
How many times do you drive to campus per week?	Drive	357	3.88	4.32
It is not safe to cross the Intersection- Sum of bikers and ped. Score.	Unsafe Cross Sum	360	4.35	2.47
How many times a week do you walk and bike to campus?	Walk Bike Sum	358	4.47	11.25

Driver's do not yield- sum of score for bikers and ped's.	Driver's Not Yield Sum	360	5.25	2.78
Speed limit is too high- sum of bikers and ped's score.	Speed Limit High Sum	360	3.61	2.16

Qualitative Variables	Variable Name	Categories	Frequency	Percent
Do you agree that there are enough locations to safely cross the intersections in the study area?	Locat. Cross Agree	Disagree Agree	152 208	42.44 57.78
How often have you driven to cross an intersection and you noticed a pedestrian/bicyclist still on the crosswalk.	Ped. On Int.	Very often Sometimes Maybe Never	103 141 69 41	29.10 39.83 19.49 11.58
Are you a Female?	Female	Yes No	230 131	63.71 36.29

The model included explanatory variables from the pedestrians and cyclists' POV about

driver's behavior and the environment and from the drivers' POV about pedestrian safety in the

study area. The response variables Y1: "Did you ever encounter any unsafe situation in the study

area as a pedestrian or bicyclist?" and Y2: "Did you ever encounter a situation where you have hit

or nearly hit a pedestrian or bicyclist while driving?" are the binary dependent variables with

categories 'Yes=1' and 'No=0'. In total, seven explanatory variables were found have significant

effects in the first model, as shown in Table 16.

Table 16:Univariate Probit Model for Pedestrian POV on Pedestrian Safety (Y1)

Variable Name	Coefficient	S.E.	P-Value
Intercept**	-1.218	0,319	0.0001
Walk Bike Sum**	0.049	0.028	0.084
Driver's Not Yield Sum**	0.191	0.059	0.001
Speed Limit High Sum**	-0.264	0.090	0.003
Unsafe Cross Sum**	0.231	0.084	0.006

Locat. to Cross Agree**[++]	0.369	0.119	0.002

**Indicates parameter is significant at 0.05 significant level

* Indicates parameter is significant at 0.10 significant level

[++] Variable has Agree as parameter reference

AIC is 183.454 (including intercepts and covariates)

The univariate probit model has a ROC area of 80.4%, indicating that the model has good classification accuracy of the data points. Positive coefficients indicate a higher response level which means the participant has had unsafe experiences or answered 'Yes' to the response questions. A negative coefficient for a predictor variable in the model indicates a safer experience. A participant who has a major issue with the speed limit in the study area indicates higher chances of safe situations in the study area as a pedestrian or bicyclist. As mentioned in the literature review, the speed limit right outside of UCF is 45 mph. If a pedestrian was struck by a vehicle at 45 mph the average survival rate is 10%. Pedestrians and bicyclists that are aware of the high speed limits and have concerns about the speed limit when crossing an intersection, being in the bike lane/sidewalks, and interacting with drivers all understand that these actions are increasingly unsafe with higher speeds and take precautions.

Participants that experience less safe situations as pedestrians and bicyclists indicate that they walk and bike more often. Collectively, the summation of trips taken per week to campus was collected for this variable. Those who are more exposed as a pedestrian or bicyclist in the area have greater chances of being involved in a vehicle crash or unsafe situation. If the road users think it is safe to travel as a pedestrian/cyclist, he/she may tend to travel more often as a pedestrian/cyclist since those travel modes may be more convenient sometimes when compared with driving a car, which would require a parking permit and drivers needs to look for a parking spot.

If a participant had a higher level of agreement with the questions asking if drivers do not yield for pedestrians and for bicyclists, it shows that the participants has had less safe experiences as a pedestrian or bicyclist. When drivers do not yield for pedestrians and bicyclists, they put the pedestrians at risk of danger. Drivers in the area may need more education on the road rules, or stronger enforcement to aid pedestrian safety.

Participants that agreed strongly that there are enough locations to cross the road have lower chances of safe experiences. Pedestrians and bicyclists that may disagree that there are enough locations to cross the road show safer experiences. This phenomenon may occur because these participants acknowledge that there are stretches of road in the study area that are too long without crosswalks and understand the dangers of jaywalking.

Agreeing that is it unsafe to cross the intersections indicates unsafe experiences as a pedestrian or bicyclist in the area. These participants may have had experiences of almost being hit or being hit by a car when crossing the intersection. Furthermore, similar to the variables of concern about drivers not yielding and agreeing that there are enough locations to cross, the participants who have concerns with such issues show that the study area need improvements for pedestrian safety.

Table 17: Univariate Probit Model for Drivers POV on Pedestrian Safety (Y2)

Variable Name	Coefficient	S.E.	P-Value
Intercept**	-1.221	0.258	0.0001
Female*[+]	-0.205	0.026	0.056
Drive	0.049	0.029	0.056
Log Unsafe Cross Sum**	0.071	0.042	0.092
Ped on Int[++]			
Very Often**	0.645	0.167	0.0001
Sometimes	0.096	0.145	0.509
Maybe*	-0.353	0.199	0.076

**Indicates parameter is significant at 0.05 significant level

* Indicates parameter is significant at 0.10 significant level

++Variable has Never as parameter reference

AIC is 274.080 (including intercept and covariates)

The univariate probit model has positive coefficients for predictor variables "Drive", 2 out of the 3 categories for "Ped. On Int", and "Log Unsafe Cross Sum". "Female" has a negative coefficient. The logistic regression model has a ROC area of 80.3%, which indicates that the model has good classification accuracy of the data points. As for drivers' experiences, participants that are female show lower indications of having hit or nearly hit a pedestrian when driving in the study area.

Participants that drive more often, similar to those who walk and bike more often, have less safe driving habits and higher chances of having hit or nearly hitting a pedestrian.

The log of the variable "Unsafe Cross Sum" has a positive coefficient, indicating that those who agree that it is unsafe to cross the intersection have experience almost hitting or hitting a pedestrian while driving. This variable has the same interpretation for the pedestrian POV model.

Table 18: Performance comparison of the univariate models

	-2Log-Likelihood *	AIC *	BIC *
Univariate Model: Y1	171.454	183.454	201.980
Univariate Model: Y2	260.080	274.08	298.327

*Indicates goodness of fit measurement is performed for Intercept and Covariates

Lower values of AIC and BIV tend to indicate a "better" model. The first model, on pedestrian safety from the pedestrian's POV, has lower AIC and BIV values (183.454 and 201.98) than the second model, which is on pedestrian safety from the drivers' POV (274.08 and 290.327). This shows that pedestrians are more familiar with pedestrian safety issues than driver's, indicating that drivers are not familiar with the issues that they cause, and may need greater levels of education on pedestrian safety techniques.

<u>5.4 Summary and Conclusions</u>

The univariate probit models for pedestrians and drivers POV about pedestrian safety were compared to each other and evaluated. The models are compared to each other using goodness of fit measurement AIC and BIC. The model of pedestrian safety from the pedestrians POV is the better model to estimate pedestrian safety issues, with lower values for both AIC and BIC.

It appears that there are several variables that contribute to safety issues for both responses. The more one walks, bikes, and drives per week contributes to less safe experiences, perhaps due to increased exposure. A suggestion to increase pedestrian safety is to increase education for both pedestrian and drivers about proper behaviors when interacting with each other. People who are not familiar with the correct etiquette for pedestrians may make risky decisions. Drivers who may not know the laws about pedestrian safety may perform unsafe behaviors. Around campus, signs or courses could be installed or taught to teach the UCF community safer pedestrian and driving habits. Increasing enforcement may also encourage drivers and pedestrians to follow street laws, such as crossing at the crosswalks and reducing driver's speed.

Agreeing that issues of concern in the study area in regard to pedestrian safety include drivers not yielding, it is unsafe to cross the intersections, and if there are enough locations to cross, indicate less safe experiences. There are technologies such as signage and road markings

that may be clearer to drivers when pedestrians are crossing. In addition, at popular pedestrian crossing locations, raised pedestrian bridges could be installed. Moreover, if one was to say that there are not adequate locations to cross the intersection but that drivers do yield to pedestrians and bicyclists, and that it is safe to cross the intersections, they are likely to have safe situations as a pedestrian. Drivers not yielding indicates a lack of education on the driver's fault or a reckless driver. To encourage drivers to yield to pedestrian more, there could be a higher risk for the driver if they were to put pedestrians at risk. In addition, to avoid the issue of drivers not yielding and to create a safer intersection crossing experience for pedestrians, there could be a pedestrian bridge installed to avoid pedestrian interaction with drivers at the intersection all together. The issue of not having enough locations to cross can be solved by installing crosswalks or pedestrian crossing areas closer together, especially in areas where the crosswalks are far apart and there is often pedestrian jaywalking activity, such as McCullough road.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Pedestrian Safety Survey Conclusions

As discussed in the literature review, pedestrian safety issues are of special concern as pedestrian fatalities from motor vehicles are rising and more people are moving to urban areas with dense traffic. A college campus is considered an urban area with the large population in a small area. UCF has many areas of interest, such as housing and shopping, across the street from campus, which invites students, faculty, and staff to walk conveniently to reach destinations. However, certain issues were identified through a survey along with certain intersections marked as the most dangerous. The solutions to these specific issues and areas are provided in this section, as well as significant findings from modeling the survey results. The solution explored in this thesis is pedestrian to vehicle warning systems through P2V communications as tested in a driving simulator.

The campus pedestrian safety survey analysis showed that drivers do not pay attention to pedestrians and the hot weather is a major concern for pedestrian safety. Drivers tend to show satisfaction with the study area, indicating that the drivers are not aware of pedestrian's issues. Finally, intersections of concern included heavily populated intersections on campus, such as intersections at the most popular parking garages and the gym, and the intersection on the campus perimeter.

One suggestion in order to reduce on campus pedestrian crashes is to displace the vehicles. Cars can be moved to the outer ring of campus with shuttles transporting people into the heart of campus. Parking can also be more expensive or prohibited for freshman in order to reduce the number of vehicles on campus.

6.1.1 Crosswalks and Signals

Only 8% of survey participants strongly agreed that there are enough locations in the study areas to cross the road safely as a bicyclists or pedestrians. When a pedestrian crosses the crosswalk, they must be able to do so in the allocated time, monitor conflicting movement (turning cars, cars running the red light, bikes), and understand the pedestrian crossing signal indication.

Most participants (50%) said that they agree that the signal timing is not enough for bikers to safely cross an intersection. While the traditional (and current signal process in the study area) includes a pushbutton for pedestrians, automated detection has proved more effective. Automated detection will activate the pedestrian phase of a traffic signal and adjust the phase time to that of the current pedestrians using the crosswalk, to extend or shorten the walking time. In 2009 the Manual on Uniform Control Devices for Streets and Highways (MUTCD) decreased standard walking speed from 4.0 feet per second to 3.5 feet per second, allowing for longer pedestrian crossing times. Signal timing, cycles length and signal phasing affect conflicts areas.

70% of participants had some concern that it is not safe to cross the intersection. Only 6% of participants strongly agree that the midblock and intersections are safe to cross in the study area. Midblock, or non-intersection locations, account for half of pedestrians injured in crashes and 77% of pedestrian fatalities in crashes.

A solution to crosswalk or crossing signal issues is to restrict right turns on red. When the light is red, drivers that wish to turn right are supposed to fully stop at the stop line before making the turn. At the time of the red right turn light, the pedestrian crosswalk signal is often signaling for pedestrians to cross the intersection. If drivers do not stop fully or yield for the

pedestrians right of way, the pedestrians are in danger. Restricting right turn on red can solve this issue.

6.1.2 Drivers Respect and Visibility of Pedestrians

Only 6% of participants strongly agree that drivers can easily recognize that pedestrians and bicyclists are crossing the street. 33% of participants who drive regularly to school have been in an incident where they have hit or have nearly hit a pedestrian or bicyclist while driving. 80% of participants have at least some concern that drivers do not yield for bicyclists and pedestrians.

In an area where a pedestrian crossing the road may be obstructed from view, the P2V warning system will help prevent pedestrian crashes. This may include foliage or structures that are blocking the driver's point of view. In addition, in dimly lit areas or common jaywalking areas P2V will be lifesaving.

6.1.3 Pedestrian Facilities

In the survey, a concern that was commonly agreed with was that it is too hot to ride a bike or walk outside. In addition, speed limits on the streets are high and there are not sidewalks and bike lanes along all sides of the roads along campus. Solutions to these issues and to increase pedestrian safety include street design and sidewalk design with safety intentions for all road users.

Complete Streets, the national effort to include all users on the streets, emphasizes the importance of sidewalks and pedestrian conditions. In the 1960's streets were being built for the purpose of automobiles, overlooking pedestrian facilities. Sidewalks were either poorly placed alongside a highway with no buffer or in total lack of funding. The absence of sidewalks forces the pedestrian to cross in undesirable locations, resulting in less walking causing an undesirable

effect for the health of the community. Recommendations for lack of sidewalk in certain areas around campus are to identify inadequate pedestrian facilities, prioritize needs for sidewalk construction, and examine funding options. Design also needs to keep in mind that our population is living historically longer than before, and elderly pedestrians may have low vision or use a wheelchair. Pedestrians physical capabilities must be understood in order to create safe environments for pedestrians who may not be legally blind but are especially vulnerable on the roadways. Signage and markings must be recognizable for all pedestrians. Lighting and glare can greatly affect signal or sign appearance. In order to make crosswalks and sidewalks safer for visually impaired pedestrians, guidelines and field tests must be done to ensure the best field materials for the specific location.

The built environment is often a determinant of pedestrian and vehicle activity and pedestrian exposure to vehicular traffic. Characteristics of the environment, such as line of sight, curbs, driveways, and the presence of specific land uses, affect safety. Roadway features can be modified to increase safety and mobility. Suggestions are to narrow lanes, raise crossings, include speed humps, incorporate traffic mini circles, and add chicanes. Presence of street parking, fixed objects, such as trees, poles, or signs, and curbs and gutters may affect motorist and pedestrian behavior.

6.1.4 Intersections of Concern

Pedestrian crashes, despite being the issue of topic, are seemingly unrelated and isolated in comparison to vehicle crashes. In order to find intersections or pedestrian locations that need to be prioritized for safety implementations, a recommended practices guide can be followed to assist State and local agencies to identify areas of concern. High crash areas can be identified to

implement engineering and other countermeasure to provide resolution for those areas. GIS can be used to find crash heavy locations.

Intersections of concern indicate that heavily populated intersections on campus, and leading off campus, are of interest. One of which, being Alafaya Trail and University Boulavard. This intersection includes a crosswalk on all four legs, with the longest crossing distance being 130 feet across 9 lanes of traffic. Three legs of the intersection have a speed limit of 45 miles per hour, with the fourth leg leading into campus has a speed limit of 30 mile per hour. This intersection has bike lanes on all sides of each leg of the road, as well as crosswalks with crossing signals. Other intersections of concern are on campus at the intersections of Gemini Boulevard and the CFE arena, which are popular for student's everyday use. These two intersections, which are 333 feet apart, are used to reach one of the gyms on campus, campus housing, one of the campus bookstores, athletic facilities, several parking garages, and various restaurants on campus. Being on campus, these two 4 leg intersections have all 4 legs of roadway with a speed limit of 30 miles per hour. There are bike lanes for all roads on campus, as well as crosswalks with a verbal crossing signal. The intersection with concern from most of the participants is the intersection of Gemini Boulevard and Research Parkway. The intersection in front of the UCF gym had the second most concern.

The Federal Highway Association (FHWA) created a 15 year strategic plan for pedestrian safety in 2010. They identified that there is a need for guidance materials for the general public as well as guidance from a community activist perspective instead of an engineering perspective. This guidance could be in the form of flyers and posters displaying pedestrian and bicycle safety rules, grade school curriculum on the subject, condensed materials for public meetings, and materials appropriate for colleges. Topics to include in guidance include how to safely be a

pedestrian or bicyclist in a rural area with no sidewalk or bike lane and guidance n pedestrian friendly walkway planning. Stakeholders, from a one day workshop in 2008, stated that the areas of pedestrian safety that are of the most significant research are vehicle speed and design of roadways that include pedestrians and bicyclists.

6.2 Pedestrian to Vehicle Driving Simulation Study Conclusions

In two scenarios, brake to maximum brake reaction time decreased in seconds by 42.5% with the P2V warning system implemented. The number of collisions reduced by 88% with the P2V warning systems. The USDOT estimates that P2V communication systems will eliminate 80% of crashes, which is supported by the results of this thesis. Mean deceleration had an 86% change on average for both scenarios with the warning system. Maximum deceleration increased by 20% with usage of the warning system. Minimum distance, mean deceleration, and maximum deceleration were all significantly more for data with the P2V warning system in use. The number of collisions and BTMB time was significantly less for data with the P2V warning system in use. This proves that this system is effective for increasing drivers' awareness and avoiding pedestrian crashes. In addition, the comparison of these variables between two scenarios shows that the P2V warning system would be more effective in pre-crash scenarios in which the pedestrian was obstructed from view than those pre-crash scenarios in which the pedestrian was observable.

The unpredictable behavior and path of pedestrians calls for more studies in the future implementing P2V connectivity in different conditions and landscapes. One limitation of driving simulator studies is that the mechanism is not entirely representative of a car with certain features, such as the brakes and steering wheel, having unique characteristics. Participants may

also lack the true importance of avoiding pedestrian crashes while driving in the simulator, knowing that in reality no one was hurt.

Motorists and pedestrians alike are using cell phones more than ever on the roads. Drivers using cell phones have a direct link to perception-reaction time, observing traffic control devices, and communicating with other road users. Pedestrian usage of cellphones affects their perception-reaction time, observation of traffic control devices, and monitoring their immediate environment, such as failing to see a car coming, potential for tripping and following unpredictable paths. Because the pedestrian is the most vulnerable road user, understanding the hazards of handheld devices to pedestrian safety is important.

6.2.1 Pedestrian Detection

Most of the scenarios in the driving simulator include pedestrian dash out's, where the pedestrian is not visible to the driver and suddenly dashes into the street. The pedestrian may be hidden behind a car or wall, or there may be low visibility due to inclement weather or low lighting in the nighttime. To prevent pedestrian dash out's in a pedestrian heavy area at a crosswalk, automated pedestrian detection technologies can be used, such as the P2V warning system.

In addition, to detect pedestrians and warn drivers to have caution, variables signs could be placed in areas of need. A variable sign has messages that can be changed, such as warning drivers that pedestrians are prominent during peak pedestrian activity hours, or during the dark.

6.3 Survey Model on Pedestrian Safety Issues Conclusions

Two univariate probit models for pedestrians and drivers POV were created to represent the survey data. The models were formed from the pedestrian safety survey. The more one walks, bikes, and drives per week contributes to less safe pedestrian experiences, perhaps due to increased

exposure. Agreeing that issues of concern in the study area in regard to pedestrian safety include drivers not yielding, it is unsafe to cross the intersections, and if there are enough locations to cross, indicate fewer safe experiences. Drivers not yielding indicates a lack of education on the driver's fault or a reckless driver. The issue of not having enough locations to cross can be solved by installing crosswalks or pedestrian crossing areas closer together, especially in areas where the crosswalks are far apart and there is often pedestrian jaywalking activity, such as McCullough road.

6.4 Final Remarks

To expand upon this thesis, a driving simulator study testing P2V warning systems could be performed with a campus type environment as the scenario. In addition, the results from the survey could lead to information for traffic enforcement officials to further investigate the specific reasons for pedestrian safety issues near college campuses. Officials can perform observations at the intersections specified in the survey. In addition, education for drivers and pedestrians in the area could be highly beneficial.

APPENDIX A: SURVEY QUESTIONNARE

This study is conducted by the transportation group of UCF's Department of Civil, Environmental and Construction Engineering in conjunction with FDOT. This study aims to evaluate the facilities related to UCF shuttle service, pedestrians and bicyclists in or around the UCF campus (shown in the following figure). Please answer the following questions based on your experience. The objective is to improve the road safety on the UCF campus.

Thank you for the kind help.
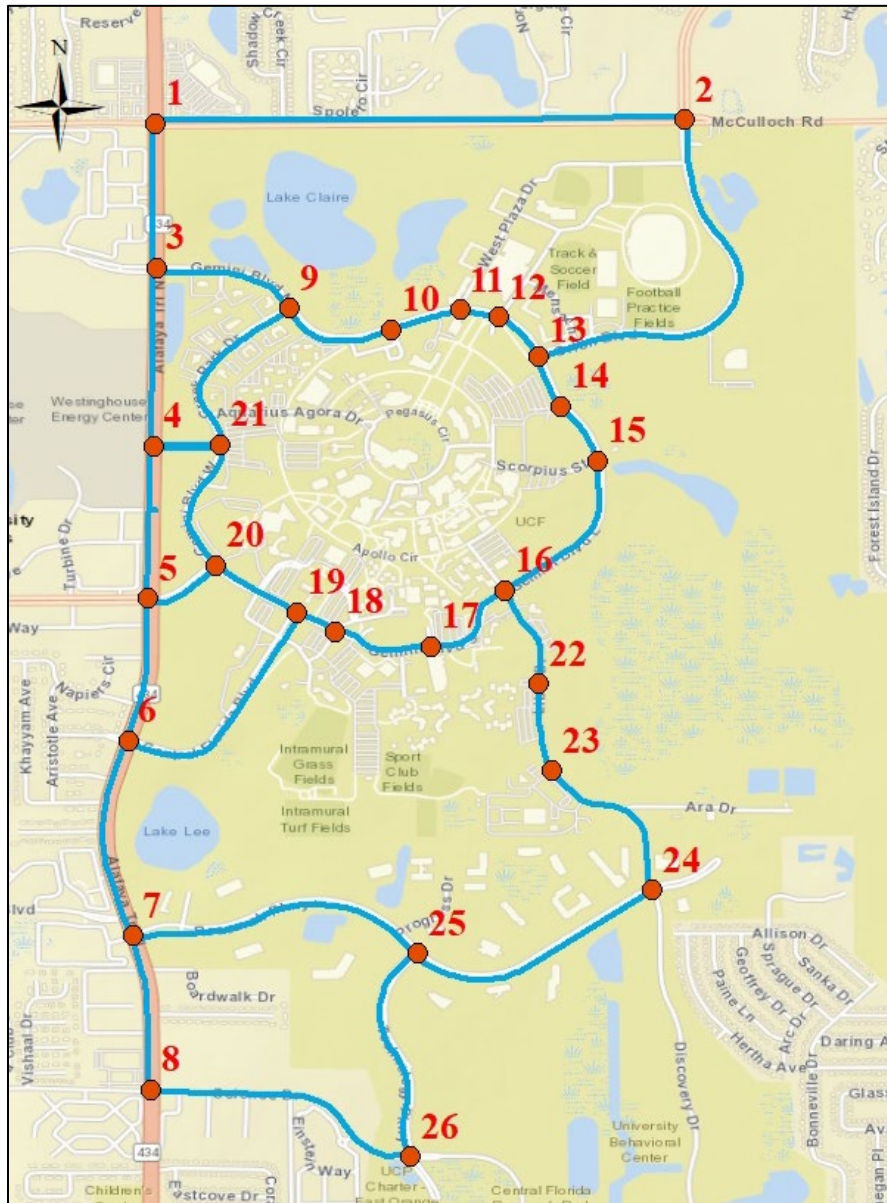
1. How often do you use the following transportation modes when you travel to and within the study area?

a) Drive a car (_____times per week)

b) Walk (_____times per week)

c) Ride a bike (_____times per week)

d) Take a bus/shuttle (_____times per week)

e) Other: _____(_____ times per week)

2. How often do you carpool to campus/back to home?

a) Very Frequently

b) Frequently

c) Occasionally

d) Rarely

e) Never

3. How do you usually receive traffic/travel information of the study area? (select all that apply)

a) Radio

b) Social media (e.g., Twitter)

c) Website/Smart phone App (e.g., google maps)

d) UCF App

e) UCF email or message

f) Don't receive traffic/travel information

g) Other: _____

If you select "f" in Question 3, please skip Question 4.

4. The traffic/travel information regarding the study area is reliable.

a) Strongly disagree

b) Disagree

c) Don't know

d) Agree

e) Strongly agree

5. The signal time allocated for pedestrians is enough for pedestrians to cross an intersection safely.

a) Strongly disagree

b) Disagree

c) Don't know

d) Agree

e) Strongly agree

Please mark the intersection shown in the map has the highest priority that you think need to increase the signal time for pedestrians: Intersection #_____

6. What are the major concerns for you to walk in the study area? Please give a score from 1 to 5 for the following elements. 1 represents little concern; 5 represents major concern.

a) Drivers do not yield for pedestrians (Score:)

b) It is not safe since speed limit on the street is too high (Score:)

c) There are not enough sidewalks (Score:)

d) It is not safe to cross the intersection (Score:)

e) It is too hot to walk outside (Score:)

f) Others: (Score:)

7. There are adequate bike lanes for bicyclists to ride bikes in the study area

a) Strongly disagree

b) Disagree

c) Don't know

d) Agree

e) Strongly agree

Please mark the segment shown in the map has the highest priority that you think need to add bike lanes: segment between Intersection # _____ and Intersection #_____

8. The signal timing is enough for cyclists to cross an intersection safely.

a) Strongly disagree

b) Disagree

c) Don't know

d) Agree

e) Strongly agree

Please mark the intersection shown in the map has the highest priority that you think need to increase the signal time for bicyclists: Intersection #_____

9. What are the major concerns for you to ride a bicycle in the study area? Please give a score from 1 to 5 for the following elements. 1 represents little concern; 5 represents major concern.s

a) Drivers do not yield for bicyclists (Score:)

b) It is not safe since speed limit on the street is too high (Score:)

c) There are not enough bike lanes (Score:)

d) There are not enough bike parking and it is hard to find bike racks (Score:)

e) It is not safe to cross intersections (Score:)

f) It is too hot to ride a bike outside (Score:)

g) Others: (Score:)

10. Did you ever encounter any unsafe situation in the study area as a pedestrian or bicyclist?

a) Yes

b) No

c) Don't remember

If yes, please mark the intersection and segment shown in the map are most likely to encounter any unsafe situation:

Intersection #_____; segment between Intersection #___ and intersection #_____

There are **enough** locations (either at the intersections or other locations) in the study area provided for pedestrians/bicyclists to cross the roads safely.

a) Strongly disagree

b) Disagree

c) Don't know

d) Agree

e) Strongly agree

11. Did you ever encounter any situation that you have hit or nearly hit a pedestrian or bicyclist while driving?

a) Yes

b) No

c) Don't remember

If yes, please select the intersection and segment shown in the map are most likely to encounter such situation:

Intersection #_____ ; segment between Intersections #___ and intersection #_____

12. Suppose you are driving to cross an intersection (make a turn or drive through). At this time, you notice a pedestrian/bicyclist is still on the crosswalk. How often have you experienced this situation?

a) Very often

b) Sometimes, remember several times

c) Maybe, cannot remember clearly

d) Never

If you have such experience, please mark the intersection shown in the map is most likely for you to meet such situation: Intersection #____

13. The mid-blocks and intersections in the study area are safe for pedestrians/bicyclists to cross the road. Drivers can easily recognize that pedestrians/bicyclists are crossing the street.

a) Strongly disagree

b) Disagree

c) Don't know

d) Agree

e) Strongly agree

Suppose you are a driver, please mark the intersection shown in the map is most likely for you to have difficulty to recognize pedestrians or bicyclists: Intersection #____

14. Do you use the UCF shuttle service?

a) Yes

b) No

If yes, please answer Question 16 and 17

15. Please select the reason(s) that you use the UCF shuttle service (select all that apply).

a) Save money

b) Save time

c) Environmental friendly

d) Do not own a vehicle

e) Others: _____

16. How do you usually obtain UCF shuttle information?

a) Radio

b) Social media (e.g., Twitter)

c) Website/Smart phone App (e.g., google maps)

d) UCF App

e) UCF email or message

f) Don't receive traffic/travel information

g) Other: _____

If no, please answer question 19.

17. Please select the reason(s) that you do not use the UCF shuttle service (select all that apply)

a) Not available near home

b) The distance to the shuttle stop is too long

c) Long waiting time

d) Own a vehicle

e) Spend longer time on shuttle

f) Others:_____

18. Is your place of residence served by UCF shuttle service?

a) Yes

b) No

c) Not sure

If yes, please answer the following questions (Question 21 to 25):

19. I am very satisfied with the UCF shuttle schedule.

a) Disagree strongly

b) Disagree

c) Neither agree or disagree

d) Agree

e) Agree strongly

20. What is the distance between your place of residence and the closet UCF shuttle schedule?

a) Within 3 minute walk

b) 3-5 minute walk

c) 6-10 minute walk

d) 11-20 minute walk

e) More than 20 minute walk

21. The shuttles always arrive on time.

a) Disagree strongly

b) Disagree

c) Neither agree or disagree

d) Agree

e) Agree strongly

22. My place of residence is the first/last stop of the UCF shuttle route.

a) Yes

b) No

c) Not sure

23. During what time periods do you use UCF shuttle service? (Select all that apply)

a) 5:00 AM - 7:00 AM

b) 7:00 AM – 9: 00 AM

c) 9:00 AM – 11:00 PM

d) 11:00 AM – 1:00 PM

e) 1:00 PM – 3:00 PM

f) 3:00 PM – 5:00 PM

g) 5:00 PM – 7:00 PM

h) 7:00 PM – 9:00 PM

i) 9:00PM – 11:00 PM

j) Others:_____

24. Do you live on the UCF campus?

a) Yes

b) No

c) Prefer not to tell

If yes, please answer Question 25.

25. Which intersection is closest to the place that you live?
(For example: Intersection 1)

If no, please answer Question 26:

26. What is the zip code of your residence?

_____

27. Which of the following ranges best describes your age?
a) 18-24
b) 25-34
c) 35-44
d) 45-54
e) 55-64
f) 65-74
g) 75-84
h) 85 and over

28. What is your gender?
a) Male
b) Female
c) Prefer not to tell

29. Which is the highest level of education you have completed?
a) Middle school
b) High school/GED
c) Associate's degree
d) Bachelor's degree
e) Master's degree

f) Doctoral degree

g) Professional degree

h) Prefer not to tell

30. Which is the best description of your role on campus?

a) Undergraduate Student

b) Graduate Student

c) Faculty

d) Staff

e) Other: _____

31. How many cars are available to you?

a) 0

b) 1

c) 2

d) More than 2

APPENDIX B: UCF INTERSECTIONS

Intersection Streets		Intersection Number
McCulloch Rd	Alafaya Trail	1
McCulloch Rd	N Orion Blvd	2
Alafaya Trail	Gemini Blvd	3
Alafaya Trail	Centaurus Blvd	4
Alafaya Trail	University Blvd	5
Alafaya Trail	Central Florida Blvd	6
Alafaya Trail	Research Pkwy	7
Alafaya Trail	Science Dr	8
Gemini Blvd	Greek Park Dr	9
Gemini Blvd N	Parking Garage H	10
Gemini Blvd N	W Plaza Dr	11
Gemini Blvd N	E Plaza Dr	12
Gemini Blvd N	N Orion Blvd	13
Gemini Blvd E	Scorpius St	14
Gemini Blvd E	Scorpius St	15
Gemini Blvd S	Libra Blvd	16
Gemini Blvd S	Hydra Ln	17
Gemini Blvd S	Pyxis Ln	18
Gemini Blvd S	Central Florida Blvd	19
Gemini Blvd S	University Blvd	20
Gemini Blvd W	Centaurus Blvd	21
Libra Drive	Bus loop by Libra garage	22
Libra Drive	UCF Police Department	23
Research Pkwy	Libra Drive	24
Research Pkwy	Technology Pkwy	25
Science Drive	Technology Pkwy	26

APPENDIX C: PRELIMINARY SIMULATOR PARTICIPANT SURVEY

1. How old are you?

   _____

2. What is your gender? Please circle the one best describes you.
   A. Male   B. Female

3. What is your ZIP code (9-digit, on your driver license)?

					--				

4. What is your highest level of education?
   a. Less than high school diploma
   b. High school diploma
   c. Associate bachelors' degree
   d. Bachelor's degree
   e. Advanced degree or professional degree

5. Are you a professional driver / Does your job involve driving?
   a. Yes
   b. No

6. How long have you been driving a car?

   _____

7. How many years have you been driving in Florida?

   _____

8. Where did you learn how to drive?
   a. In Florida
   b. Outside Florida, but in United States
   c. Outside United States

9. What vehicle do you usually drive?
   a. Passenger Car
   b. Light Truck or Van
   c. Motorcycle

APPENDIX D: PRELIMINARY SIMULATOR PARTICIPANT RATINGS

Please answer each statement as honestly as you can.

Always-3   Often-2   Sometimes-1   Never-0

Question   Score

1. Get angry at drivers.   _____

2. Get angry at fast drivers.   _____

3. Get angry at slow drivers.   _____

4. Get angry when cut off.   _____

5. Get angry at malfunctioning stoplights   _____

6. Get angry at traffic jams   _____

7. Spouse or friends tell you to calm down.   _____

8. Get angry at tailgaters.   _____

9. Get angry at your passengers.   _____

10. Get angry when multilane highway narrows   _____

11. Impatient waiting for passengers to get in.   _____

12. So impatient, won't let car engine warm up.   _____

13. Impatient at stoplights.   _____

14. Impatient waiting in lines (car wash, bank).   _____

15. Impatient waiting for parking space.   _____

16. As passenger, impatient with driver.   _____

17. Impatient when car ahead slows down.   _____

18. Impatient if behind schedule on a trip.   _____

19. Impatient driving in far right, slow lane.   _____

20. Impatient with pedestrians crossing street. _____

Always-3   Often-2   Sometimes-1   Never-0

21. Compete on the road. _____
22. Compete with yourself. _____
23. Compete with other driver. _____
24. Challenge other drivers. _____
25. Race other drivers. _____
26. Compete with cars in tollbooth lines. _____
27. Compete with other cars in traffic jams. _____
28. Compete with drivers who challenge you. _____
29. Compete to amuse self when bored. _____
30. Drag race adjacent car at stop lights. _____

31. Do you "punish" bad drivers. _____
32. Complain to passengers about other driver. _____
33. Curse at other drivers. _____
34. Make obscene gestures. _____
35. Block cars trying to pass. _____
36. Block cars trying to change lanes. _____
37. Ride another car's tail. _____
38. Brake suddenly to punish tailgater. _____
39. Use high beams to punish bad drivers. _____

40. Seek personal encounter with bad drivers. _____

APPENDIX E: POST SIMULATOR PARTICIPANT SURVEY

1. How do you feel? Are you capable of leaving or need some time to rest?

2. Do you have any suggestions or feedback on how to improve the simulation or have any complaints in regards to the scenarios you ran?

3. Do you think the scenarios were logical and realistic to an actual life situation?

4. What did you like and dislike about the simulation?

5. Under the simulator environment, how helpful were the "Pedestrian Crossing"?

1	2	3	4	5
Not at all helpful	Not very helpful	Somewhat helpful	Helpful	Very helpful

6. Under the simulator environment, how helpful was the "Keep Distance" Warning?

1	2	3	4	5
Not at all helpful	Not very helpful	Somewhat helpful	Helpful	Very helpful

APPENDIX F: PEDESTRIAN SURVEY IRB FORM

UNIVERSITY OF CENTRAL FLORIDA

EXEMPTION DETERMINATION

June 10, 2019

Dear Mohamed Abdel-Aty:

On 6/10/2019, the IRB determined the following submission to be human subjects research that is exempt from regulation:

Type of Review:	Initial Study, Category 2
Title:	A survey to understand the public's opinion about the autonomous vehicle
Investigator:	Mohamed Abdel-Aty
IRB ID:	STUDY00000547
Funding:	None
Grant ID:	None

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made, and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request so that IRB records will be accurate.

If you have any questions, please contact the UCF IRB at 407-823-2901 or irb@ucf.edu. Please include your project title and IRB number in all correspondence with this office.

Sincerely,

Racine Jacques, Ph.D.
Designated Reviewer

APPENDIX G: DRIVING SIMULATOR STUDY IRB FORM

Institutional Review Board
FWA00000351
IRB00001138Office of Research
12201 Research Parkway
Orlando, FL 32826-3246

APPROVAL

May 22, 2019

Dear Mohamed Abdel-Aty:

On 5/22/2019, the IRB reviewed the following submission:

Type of Review:	Modification and Continuing Review
Title:	Evaluation the Impact of Connected Vehicle Technologies and Managed Lane Facilities based on Driving Simulator Experiments
Investigator:	Mohamed Abdel-Aty
IRB ID:	MODCR00000139
Funding:	Name: University of Iowa
Grant ID:	None
IND, IDE, or HDE:	None
Documents Reviewed:	• questionnaire, Category: Survey / Questionnaire; • Flyer, Category: Recruitment Materials; • irb_HRP-503 - PROTOCOL_2018simulation_V4.docx, Category: IRB Protocol; • consent_form_2018_simulator_revised.pdf, Category: Consent Form; • questionnaire, Category: Survey / Questionnaire;

The IRB approved the protocol from 5/22/2019 to 5/21/2020.

In conducting this protocol, you are required to follow the requirements listed in the Investigator Manual (HRP-103), which can be found by navigating to the IRB Library within the IRB system.

If you have any questions, please contact the UCF IRB at 407-823-2901 or irb@ucf.edu. Please include your project title and IRB number in all correspondence with this office.

Sincerely,

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