**Florida Department of Transportation Contract BDV31-977-99**

# University of Florida (UF) Testbed Initiative – Alternative Transportation Safety Systems

## Final Report

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**University of Florida**

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# Disclaimer

# Metric Conversion Table

| SYMBOL | WHEN YOU KNOW | MULTIPLY BY | TO FIND | SYMBOL |
|---|---|---|---|---|
| | | **LENGTH** | | |
| **in** | inches | 25.4 | millimeters | mm |
| **ft** | feet | 0.305 | meters | m |
| **yd** | yards | 0.914 | meters | m |
| **mi** | miles | 1.61 | kilometers | Km |
| **mm** | millimeters | 0.039 | inches | in |
| **m** | meters | 3.28 | feet | ft |
| **m** | meters | 1.09 | yards | yd |
| **km** | kilometers | 0.621 | miles | mi |
| | | **AREA** | | |
| **$in^2$** | square inches | 645.2 | square millimeters | $mm^2$ |
| **$ft^2$** | square feet | 0.093 | square meters | $m^2$ |
| **$yd^2$** | square yard | 0.836 | square meters | $m^2$ |
| **ac** | acres | 0.405 | hectares | ha |
| **$mi^2$** | square miles | 2.59 | square kilometers | $km^2$ |
| **$mm^2$** | square millimeters | 0.0016 | square inches | $in^2$ |
| **$m^2$** | square meters | 10.764 | square feet | $ft^2$ |
| **$m^2$** | square meters | 1.195 | square yards | $yd^2$ |
| **ha** | hectares | 2.47 | acres | ac |
| **$km^2$** | square kilometers | 0.386 | square miles | $mi^2$ |
| | | **VOLUME** | | |
| **fl oz** | fluid ounces | 29.57 | milliliters | mL |
| **gal** | gallons | 3.785 | liters | L |
| **$ft^3$** | cubic feet | 0.028 | cubic meters | $m^3$ |
| **$yd^3$** | cubic yards | 0.765 | cubic meters | $m^3$ |
| **mL** | milliliters | 0.034 | fluid ounces | fl oz |
| **L** | liters | 0.264 | gallons | gal |
| **$m^3$** | cubic meters | 35.314 | cubic feet | $ft^3$ |
| **$m^3$** | cubic meters | 1.307 | cubic yards | $yd^3$ |
| NOTE: Volumes greater than 1000 L shall be shown in $m^3$. | | | | |

# Technical Report Documentation Page

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16. Abstract

Public transit operators experience a variety of challenges on a daily basis, and advanced driver assistance systems (ADAS) have the potential to decrease crash risks or conflicts associated with transit operation, which could result in a more safe, efficient, and economical service. This study evaluated the safety implications of the Mobileye Shield+ system. This ADAS system was procured and installed on 10 Regional Transit System (RTS) buses in Gainesville, Florida. The study collected data on conflicts detected by the ADAS during stealth mode, during which drivers did not receive alerts, and active mode, during which drivers received alerts. A before-and-after analysis was conducted over a period of one year of operation. The vendor's visualization interface was explored for analysis; however, manual analysis was adopted for route-based evaluation. Transit operators were interviewed through a focus group study to seek feedback. Lastly, the study developed a benefit-cost analysis tool that utilized crash history along with surrogate safety assessment parameters to predict the rate of return of ADAS investment. Overall, data analysis results showed a reduction in transit bus and pedestrian-related conflicts with the installation of ADAS. Even though transit operators preferred the system, they were concerned about sensitivity and false positive alerts. The benefit-cost analysis tool revealed that these systems would benefit agencies meeting certain criteria, including agencies with high historical crashes, higher vehicle revenue miles, and large transit fleets.

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# Executive Summary

Public transit operators experience a variety of challenges on a daily basis. Though transit crashes are low in frequency, they have resulted in fatalities or serious injuries. In 2015, Florida experienced the highest state increase (17.8%) in transit fatalities and was ranked the third in the nation. In Gainesville, the Regional Transit System (RTS) experienced 13 collisions in 2019 (FTA, 2020), in which 10 people were injured, including three passengers, three employees, and four other vehicle occupants (FTA, 2020). In addition to crash cost, agencies incur liability expenses. Between 2015 and 2018, the average casualty and liability expenses for the Gainesville Regional Transit System (RTS) was $1,274,808 (FTA, 2018). RTS provides bus service to almost 40,000 transit trips per day. Advanced driver assistance systems (ADAS), also known as collision avoidance systems (CAS), have the potential to decrease crash risks or conflicts associated with transit operation which, could result in a more safe, efficient, and economical service.

The focus of this study was to explore the safety implications of a vision-based ADAS called Mobileye Shield+. The goal of this study was to evaluate the effectiveness of the Mobileye Shield+ to reduce conflicts between transit buses and pedestrians and bicycles. To achieve this goal, a research plan was developed to (1) identify a behavioral and infrastructure condition that leads to incidents or near incidents, (2) assess the perceived acceptance and usefulness of the system to drivers, and (3) develop a benefit-cost analysis tool to analyze the financial justification of ADAS.

## E.1 System Installation, Alerts, and Ituran Visualization

Mobileye Shield+ was installed on 10 RTS transit buses that operated on the University of Florida's campus circulator routes. The Mobileye Shield+ was installed on buses between Jan. 4 and Jan. 7, 2019. The Mobileye Shield+ system includes camera sensors, two exterior sensor housings, and two interior windshield-mounted vision sensors. The Mobileye Shield+ system includes three driver alert displays that communicate with the driver by visual and audible alerts.

The system operated in stealth mode for the first two months, between Jan. 5, 2019, and Mar. 4, 2019; alerts were disabled, but data were being recorded. The system then operated in open mode for almost 12 months, between March 5, 2020, and Feb. 29, 2020 (422 days in total); the different visual and audible alerts were broadcasted to the driver. The alerts that were in the focus of this study were pedestrian detection (PD), pedestrian collision warning (PCW), urban forward collision warning (UFCW), forward collision warning (FCW), headway warning (HWW), and aggressive braking (AggBrk).

Ituran is a Web-based visualization and data repository tool that displays the data from each bus's telematics system in a Web interface. The time and location of all alerts from Mobileye Shield+ are displayed, and various reports can be generated. Data of individual conflicts were retrieved for analysis from the Ituran interface.

## E.2 Data Collection Plan and Challenges

The data cleaning and quality control checks revealed missing data feed for three buses. Further investigation revealed that the missing information was a result of malfunction. The first bus did not report any data after March 2019. The second bus had a low number of conflicts recorded, which was unusual. The third bus reported relatively lower data in January and February of 2019 than the rest of the year. For data consistency and to avoid any bias, the observations from these three buses were not included in the analysis. It was also found that buses changed route sporadically based on agency and community needs. However, the data generated by randomizing the buses and the routes aided statistical significance by avoiding any route familiarity bias that may have occurred if drivers navigated the same route daily for a prolonged period.

The data analysis task was twofold: first, an aggregate analysis including conflicts from all buses; and second, a route-based analysis. For both analyses, the raw Mobileye data were utilized instead of the built-in reports from Ituran. In addition to data scrubbing and manually correlating routes to buses, there were several challenges faced during the process, and as a result, a comprehensive data cleaning and structure integrity task was undertaken.

### E.2.1 Data Cleaning and Structure

An FTP feed was set up to receive the daily log of all alerts data. The data were read and scrubbed in R, a programming language oriented toward statistical computing. Preliminary analysis revealed inconsistencies in the number of records in some rows with many containing ^KEEPALIVE^ error rows. These rows were eliminated, and the data were cleaned to develop a consistent and structured database.

### E.2.1 Route Data

For route-based analysis, a visual methodology was devised to determine the route of each bus for each day using the footprints of alerts (latitude, longitude). There were a total of 2,954 plots (422 days × 7 buses). On most weekends. there were not enough data to correlate the footprints with RTS bus routes. As a result, only weekdays routes were correlated, which included data for 2,100 days (422 days × 5 buses). Of the 2,100 days, 707 had no alert to be used for route identification. Overall, the routes for 1,341 vehicle-days were defined, and 52 were not correlated.

## E.3 Performance Evaluation

### E.3.1 Aggregate Analysis

Data from seven RTS buses were combined to assess the hourly, daily, and monthly distribution of alerts. In addition, the developed database was utilized to compare the observed number of alerts in stealth and open modes. As expected, there were three peaks in the distribution during the morning, noon, and afternoon peak hours. However, all the plots followed a bell-shaped pattern. The data were further analyzed by categorizing the conflicts in different speed groups. The distribution of HWW and PDZ conflicts with speed more than 20 mph showed conflicts having three distinct peaks in the morning, noon, and early evening. As hypothesized, there was a low number of conflicts during the weekends due to lower demand. The data analysis results also showed that less than 5% of conflicts occurred on Saturdays and Sundays and that the variance of observations for weekdays was about 17%.

Next, a monthly analysis was performed. The UF semesters were superimposed with the conflict data, revealing that the PDZ conflicts were constant throughout the study period. The observed PCWs were highest during the fall and at their lowest during the summer semester. In addition, it was observed that FCW and HWW followed a trend that was the opposite of UFCW during summer and fall semesters. This was attributed to vehicle demand and how UFCW and FCW are defined and programmed. UFCW is a collision warning alert with a speed less than 19 mph, and FCW is a collision warning alert for speeds greater than 19 mph. It was hypothesized that with lower vehicular traffic in summer, transit buses operated a higher speed, which resulted in higher FCW in summer. The AggBrk distribution had a slight decreasing trend during the study course.

#### E.3.1.2 Normalized Time Series of the Alerts

The number of conflicts was normalized to monthly vehicle miles traveled (VMT). All the normalized alerts showed a slight decreasing trend during the study period with the lowest normalized aggressive braking in September when student demand is highest, and when buses are in their fullest condition. This was hypothesized to be due to overcautious driving by RTS drivers due to sudden increase in demand during the beginning of fall semester.

#### E.3.1.3 Before After Analysis

In the before-after analysis, stealth mode is considered “Before”, and the rest of the period is “After.” The open mode period included summer semester, which had a lower exposure due to the lower number of students on campus. Ignoring the effect of varied demand could bias the results; however, there was no mechanism to quantify pedestrian exposure for the extended period and for each route length. As an alternative, two different approaches were adopted. First, data from the same semester period were used. The before data (stealth mode) were from spring semester of 2019, and after data (open mode) were from spring semester of 2020. The second approach was to aggregate all after data (open mode) and compare with before (stealth mode).

Both PDZ and PCW alerts decreased in the open mode. PDZ decreased by 13.3% when conflicts in stealth mode were compared with all active data (AAD) for the study period. PDZ decreased by 19.6% when stealth was compared to similar dates (SD) in two calendar years. PCW, which is more critical in quantifying conflict avoidance, decreased by 38.6% (AAD) and 33.4% (SD).

UFCW (speed <19 mph) decreased by 26.0% (AAD) and 26.8% (SD). The decreases in FCW warnings were 12.6% (AAD) and 29.3% (SD). The last rear-end–related warning, HWW, decreased by 26.7% (AAD) and 48.3% (SD).

Aggressive breaking decreased by 29.2% (AAD) and 47.6% (SD) in the open periods. All the warnings decreased during the open mode period, which shows the drivers’ behavior improved and that the ADAS system reduced pedestrian and vehicular conflicts. The average of all reductions (Table 5-10) is 34.17%. This translates to an average conflict modification factor (CoMF) of 65.83%.

The decrease in alerts is greater when stealth mode conflicts were compared to similar dates in active mode in 2020 (Table 5-10).

### E.3.2 Route-based Analysis

The Ituran alerts from Mobileye were correlated with the five selected routes. For this option, day-by-day data from the Ituran Safety tab were used. This approach was undertaken because the data were already aggregated for each vehicle by day. However, the initial analysis showed that the numbers from this tab (period summary daily) were about 5% in excess of the data used in aggregate analysis. Using the period summary daily data from Ituran could have biased the results. It should be noted that in the route-based analysis section, the latitude and longitude of each individual alert was required to define each vehicle’s daily route (Table 5-3), and as such, the day-by-day data from the Ituran Safety tab could not be used for both aggregate and route-based analyses.

Finally, the disaggregated alert data were correlated with routes by using key values of date and vehicle number.

#### E.3.2.1 Pedestrian-related Alerts

PCWs in open mode increased by 4.0% and 3.1% for routes 5 and 8, respectively. This is while the other routes experienced a reduction of 10.7%, 11.8%, and 25.5%.

#### E.3.2.2 Vehicular Alerts

The vehicular alerts, including FCW, UFCW, and HWW, for the five routes between stealth and open modes were analyzed. The number of FCWs in stealth mode for routes 5 and 16 were 3 and 4, respectively. The low number of observations for these two routes made conclusions statistically insignificant. The other three routes showed reductions in FCW ranging from 7.4% to 27.8%. The UFCW on all the routes showed reductions ranging between 3.7% and 35.2%. Routes 1 and 16 experienced an increase in HWWs. The other routes experienced reductions between 20.5% and 32.2%.

#### E.3.2.3 Aggressive Braking

The number of FCWs in stealth mode for routes 5 and 117 were 3 and 5, respectively. The low number of observations for these two routes makes the conclusions statistically insignificant. The other routes showed reductions ranging between 2.3% and 38.0%.

### E.3.3 Summary of Route-based Results

Most of the alerts (22 of 26) showed a reduction. Alerts showed an average reduction of 19.95%, which is equivalent to a conflict modification factor (CoMF) of 80.05%. If one of the highest values was excluded as an outlier (due to missing data after May 2019 on Route 16), the average CoMF will be 73.59%.

## E.4 Hotspot Analysis

The purpose of hotspot analysis was to identify potential risk factors for high conflict locations. Ituran includes a visualization tool that shows locations with high conflicts, called hotspots in this study. Most hotspots from Ituran were locations with high pedestrian demand but without severe risk factors. As the purpose of this study was to find locations with high risk factors in the network, a normalization methodology was developed. This methodology focused on finding locations that have a higher ratio of PCW to PDZ. Here, PDZ is considered as an exposure measure. Ituran does not have a feature to rank the locations with a selected measure. So, an algorithm was developed in R to rank the locations and produce graphical output.

To filter out a final list of hotspots for detailed analysis, the locations with more than five PCWs that have PCW-to-PDZ ratio of more than 0.2 were selected. Using the mentioned filters, 21 hotspots were found. When adjacent hotspots were combined as one (three clusters with three, two, and two hotspots, respectively), 17 hotspots remained for further review. Of these 17 hotspots, three were locations with high pedestrian demand and few severe risk factors: the RTS bus depot, Santa Fe College, and Walmart. Excluding these three locations left 14 hotspots for further review. The risk factors found for these locations were placed in five categories:

- Alignment: Curves
- Intersections: Signalized, roundabouts, offsets, Y-intersections
- Facilities: Bus stops, crosswalks

- Land use: Parking, residential, commercial, campus
- Pedestrian signal timing: Ped phase time.

## E.5 Operator Focus Groups

Five focus group sessions were held to elicit responses from bus drivers who had experienced the Mobileye Shield+ ADAS. There were four drivers scheduled for each of the sessions, but for two of the focus groups, three drivers participated.

Major themes of the sessions included the following:

- Most drivers felt that the alerts are useful, especially if someone was near the bus. Some stated that the alerts helped get the driver's attention. Some said that they felt it improved safety. Most drivers preferred having this technology on their bus.
- Most drivers that found the system useful mentioned that the system was most useful on the University of Florida campus where there are many students and increased congestion levels.
- On average, drivers ranked the alerts from most useful to least useful as follows: PCW, HWW, Speed Warning, FCW, and Lane Departure Warning.
- Of 16 drivers, only one driver was supportive of having an automatic braking system.
- Drivers often encountered the system without training or preparation. In many cases, they did not know the expected functioning of alerts and had to interpret their function from observation. In some cases, lack of training – and therefore expectation – made it impossible for drivers to detect a dysfunctional alert.
- Drivers generally reported too many alerts, alerts for no apparent reason (false alerts), alerts for stationary objects (false positive alerts), and no alert when pedestrian present (false negative alerts).

## E.6 Benefit-Cost Analysis

For any emerging technology, financial justification and cost effectiveness are essential criteria for decision makers. This study developed a macro-enabled Excel spreadsheet. This Excel spreadsheet tool (ADAS-BC_Analysis.xlsm) is delivered as a supplement to this document.

The tool uses the transit information, historical crashes, and surrogate safety measures (collected by Mobileye Shield +). A methodology was developed to convert the surrogate safety measures to a predicted number of crashes. Each conflict was correlated to all types of crashes. For each surrogate safety measure, a conversion factor, CF, was computed.

Surrogate safety data in this study were collected in Gainesville, Florida, between Jan. 2019 and Feb. 2020. The average yearly transit crash count in this city based on NTD for years 2015–2019 was 12.8 crashes per year. Using the mentioned numbers and the formula above, the CFs were found.

By a simple calculation from equation E-1 and renaming Avg Yearly Transit Crash to the total predicted transit crashes (Total Crash) formula (E-2) is derived (VRM = vehicle revenue miles):

$$\frac{\text{Avg Yearly Transit Crash}}{\text{City Transit VRM}} = \text{CF}_i \times \frac{(\text{Observed Conflicts})_i}{\text{ADAS VRM}} \quad \text{(E-1)}$$

$$\text{Total Crash}_i = \text{CF}_i \times \frac{(\text{Observed Conflicts})_i}{\text{ADAS VRM}} \times \text{City Transit VRM} \quad \text{(E-2)}$$

After finding predictions by using the various numbers of conflicts (*i*), an average of all predictions is considered to be a predicted number of crashes. The system could be in stealth mode or active mode while collecting data. The tool can compute the predicted number of crashes using either stealth mode data and active mode data. The tool uses VRMs of the two computations to find a weighted average of both. By finding the weighted average of predicted crashes and observed crashes, a methodology similar to Empirical Bayes, the expected number of crashes will be found. The benefit of the system is the equivalent cost of potential reduction in crashes.

The system cost includes the one-time installation cost, approximately $8,900, and the yearly cost of $240, based on the procurement cost for this project. The yearly costs were converted to equivalent annual cost (EAC) by the tool. The system finds a lower bound and upper bound for the benefits of the system (the details of the process are explained in section 8.3.4, Benefit of the System). The output is based on the life cycle between 5 and 12 years. The tool includes the transit and crash history data for 28 transit agencies in Florida. The user can choose any agency, and the tool imports the relevant information. For the mentioned 28 agencies, the tool was used to compute the cost effectiveness of Mobileye Shield+ with a 5-year life cycle. Because there was no surrogate safety collected by these agencies, in the tool calculations, only the crash history was used. In nine of the communities, the net benefit was positive. A CMF of 0.66 was used in the calculations. Because only the crash history was used, the results only depend on the number of observed crashes.

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# Chapter 1 – Introduction

## 1.1 Problem Statement

The Gainesville Regional Transit System (RTS) provides bus service to the University of Florida (UF), Santa Fe College (SF), portions of unincorporated Alachua County, and the city itself. The partnership between these entities has produced remarkable results over the last two decades. National Transit Database (NTD) statistics show the region has the 14th most trips per capita in the nation (Fischer-Baum, 2014) and the most trips per revenue mile in Florida (FDOT, 2016).

In Gainesville, the majority of transit trips occur by UF students, staff, and faculty. During fall and spring semesters, UF students alone make almost 40,000 transit trips per day. The start and end of these trips typically consist of pedestrian or bicycle movements. These activity levels force constant vigilance by transit drivers, particularly given the prevalence of smartphone activity, the University's strong deference to pedestrian crossing movements, and student urgency to reach class and other destinations on time. While serious safety conflicts are sporadic, they do arise and can have devastating consequences, including fatalities (Sarkissian, 2015; Varn, 2014).

In a nationwide study, Pecheux et al. (2008) reported that the annual frequency of transit pedestrian collisions was 27 per 1,000 buses. Based on the National Transit Database in 2019 (FTA, 2020), a total of 8,858 major transit safety events, including 6,506 transit collisions were reported, 224 people were killed, and 9,771 were injured. In 2015, Florida was ranked the third in the nation for the highest number of transit fatalities, and Florida also experienced the largest (17.8%) increase in fatalities. In Gainesville, RTS experienced 13 collisions in 2019 (FTA, 2020), in which 10 people were injured, including 3 passengers, 3 employees, and 4 other vehicle occupants.

Emerging technologies in transit vehicles have the potential to improve safety and mobility of bus drivers and passengers as well as non-motorists, including pedestrians and bicyclists. Currently, the collision avoidance systems rely on one of the following four technologies: (1) lidar, a radar-like system that functions at near-infrared wavelengths; (2) traditional radar-based systems; (3) ultrasonic-based sensors; and (4) computer vision systems (Lin et al., 2010). This study evaluated a computer vision-based collision avoidance system named Mobileye Shield+ (Part number part number VQS4560 ; Mobileye, Inc., New York, NY).

## 1.2 Project Objectives

The goal of this research was to evaluate the effectiveness of an advanced driver assistance system (ADAS), specifically, the Mobileye Shield+ collision avoidance system, in an effort to reduce conflicts between transit buses and pedestrians or bicycles. The project had three objectives:

1. Identify and characterize behavioral and infrastructure conditions that lead to incidents or near-incidents between transit vehicles and pedestrians or bicyclists
2. Characterize perceived acceptance and helpfulness to transit drivers
3. Develop a framework to prioritize ADAS investments for small- and mid-size transit agencies.

## 1.3 Stakeholders

The primary stakeholders in this project included the City of Gainesville and the Florida Department of Transportation (FDOT). Specifically, UF coordinated with City of Gainesville and FDOT to procure and install the Mobileye solution on 10 Gainesville RTS buses. In addition to the installation of the units, UF coordinated with Mobileye and Gainesville RTS to conduct driver training sessions to familiarize drivers with the system display messages and warnings.

# Chapter 2 – Review of Previous Evaluation Studies

Technological interventions have been adopted in the transportation industry to improve safety for several decades. The common purpose of these efforts has been to alert the drivers as early as possible that their vehicle is on a collision course with another entity on the roadway. Most technologies use simple time-space analysis to predict the time and location of different road users, and based on the operational characteristics (speed, heading, acceleration, deceleration, etc.), to predict if more than one user would potentially be in the same space at the same time. The evolution of real-time data about road users has yielded several detection and warning systems.

## 2.1 Pedestrian Detection Technology

Chen et al. (2006) tested various on-vehicle pedestrian detection technologies, including capacitance sensing, electric field sensing, computer vision, infrared, laser scanner, radar, and ultrasonic. They concluded that computer vision is more appropriate for sign detection and lane configuration. However, since 2006, computer vision has improved significantly. Vertal et al. (2015) tested the effectiveness of Volvo's pedestrian detection system and found some limitations, including dark condition, distance to pedestrian less than 80 cm, and pedestrian entering the road from the left.

## 2.2 Pedestrian Warning System (V2P)

Pecheux et al. (2008) reported that 60% of transit-pedestrian collisions occur while the transit vehicle is turning at an intersection. The use of automated and connected vehicle technologies could help drivers to better identify pedestrians and bicyclists and reduce the risk of such incidents. The Greater Cleveland Regional Transit Authority (RTA) was one of the first transit agencies that tested two different pedestrian collision warning systems which gave audible alarms while turning (Burka et al., 2014). The first system advised the bus driver to blow the vehicle's horn, and the second system used the existing backup alarm while the bus was turning. These systems were found effective, and RTA continued installing automated alarm devices.

The City of New York *Vision Zero Action Plan* (City of New York, 2014) included a study on vehicle-to-pedestrian (V2P) warnings, and infrastructure-to-everything applications were developed for Bluetooth-enabled cellphones. The goal was to use smartphones to increase the awareness of pedestrians, bicyclists, and motorists about their surroundings.

In this study, a cash reward lottery of $50,000 was announced to motivate people to use the applications.

Other agencies that have used similar V2P technologies to warn pedestrians about turning buses (audibly, visually, or both) were Maryland Transit Administration on 10 buses in 2011, Massachusetts Bay Transportation Authority on 10 buses in 2014 (Annear, 2014), Southeastern Pennsylvania Transportation Authority on 12 vehicles in 2015 (Turnbull et al., 2017), and TriMet in the Portland, Oregon, downtown area on 45 buses in 2014 (Alstadt, 2014). Benefit-cost ratio of devices tested by TriMet ranged from 4.6 to 106.6 (Pecheux et al., 2015).

## 2.3 Cyclist to Vehicle (C2V) and Cyclist to Infrastructure (C2I)

In 2014, Transport for London tested a system (CycleEye) that alerts the driver when cyclists and pedestrians are moving close to their vehicle. The pilot was a six-week test on four buses serving two routes with a high number of pedestrians and cyclists (Transport for London, 2014). The University of Minnesota Roadway Safety Institute developed and tested a sensor-based system for bicyclists to predict bicycle-vehicle crashes and alert the vehicle driver by audible horn alarm (PRNewswire, 2015). In this system, the bike is equipped with sensors, electronics, and a small computer. The preliminary results showed that the system can predict near misses effectively. Kimley-Horn and the City of Austin developed a cellphone application for bicyclists to inform the signal about the approaching bicyclist (Kimley-Horn and Associates, Inc., n.d.).

## 2.4 Vehicle-Based Collision Warning System

Turnbull et al. (2017) did a pilot study for a bus equipped with the Mobileye Shield+ system that warns the transit drivers about possible rear-end vehicular crashes and pedestrian crashes. The pilot lasted 27 days. There were 41 pedestrian collision warnings (PCW) recorded, of which 37 PCWs had a usable and viewable video. Of these 37 PCWs, the system identified all correctly; the accuracy of the Mobileye Shield+ for PCWs was 100% with no false alarms. In a follow-up study in 2017 of the 40 PCWs found four false alerts, a 10% false alarm rate.

A London-based study (Mobileye Technologies Limited, n.d.) used Mobileye Shield+ on 66 buses and reported that the driver’s behavior changed positively while using the system, with a 60% reduction in avoidable crashes. Another study (Spears et al., 2017) reported that the vehicles equipped with this system experienced 71.55% fewer forward collision warnings (FCW+UFCW) and a 43.32% reduction in pedestrian encounters in the detection zone (PDZ). The decrease in PCWs was 37.03%. The agencies that used the system suggested disabling the lane departure warnings as the transit vehicles frequently do. This is while another U.S. study (Smart Cities World, 2018) showed this alarm can possibly reduce avoidable collisions by 29%.

Hadi et al. (2019) evaluated the effectiveness of Mobileye Shield+ (a vision-based driver assistance system) in reduction of rear-end crashes and pedestrian and bicycle crashes. The research plan was to analyze the performance of 10 buses on predefined routes, but Miami-Dade County changed the bus routes during the data collection process.

Hadi et al. (2019) reviewed 60 recorded videos and measured the accuracy of the system for three alert categories: headway (HW); urban forward collision warning (UFCW; conflicts where speed is between 0.6 mph and 19 mph); and forward collision warning (FCW; conflicts where speed is more than 19 mph). The accuracy ranged between 80% and 98% for HW, 62% and 98% for UFCW, and 82% and 92% for FCW. The system had a positive effect on driver performance. Driver reaction time to rear-end conflicts and pedestrian conflicts improved by 13% and 26%, respectively.

## 2.5 Driver Assist System for Shoulder Driving Vehicles

A driver assist system (DAS) for buses was developed and tested in Minnesota to enhance driver confidence in driving on roadway shoulders, especially during adverse weather (Pessaro and Van Nostrand, 2011). This system provides lane position feedback to the driver through a heads-up display, virtual mirror, vibrating seat, and actuated steering. The DAS helped the driver stay on shoulder 10% longer with a 3-mph increase in speed. Figure 1 shows the DAS system heads-up device and virtual mirror.

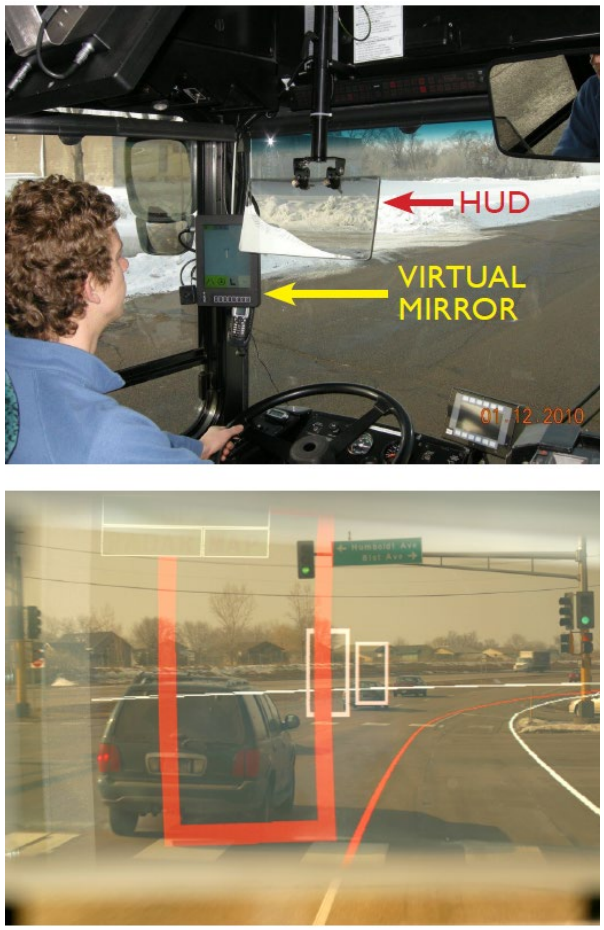



**Figure 2-1 – Driver assistance system for driving on shoulders; HUD: heads-up display (Pessaro and Van Nostrand, 2011)**

# Chapter 3 – Existing Condition

Most transit trips in Gainesville are made by UF students, staff, and faculty. During fall and spring semesters, UF students alone make almost 40,000 transit trips per day. The start and end of these trips typically consist of pedestrian or bicycle movements. These activity levels force constant vigilance by transit drivers, particularly given the prevalence of smartphone activity, the University's strong deference to pedestrian crossing movements, and student urgency to reach class and other destinations on time. While serious safety conflicts are sporadic, they do arise and can have devastating consequences, including fatalities.

Given the number of pedestrians, the high-risk population (young adults who are more frequently distracted and intoxicated pedestrians), and the density of pedestrians and vehicles, transit agencies in university towns and areas could have higher exposure to pedestrian incidents than other locales. This appears to be true for Gainesville at least.

Table 3-1 and Figure 3-1 present National Transit Database (NTD) safety information from 2015–2019. RTS experiences higher collisions and fatal and injury rates than the national average. When normalized by vehicle revenue hours, RTS is involved in 39.5% more incidents that result in pedestrian and bicyclist injuries. This is while the fatal and injury rate (person/million VRH) for RTS is 11.6% higher than the national average.

There is a severe monetary penalty for these incidents. Despite the fact that transit is significantly safer than driving, agency liability expenses are increasing at almost 3% per year and average approximately $6,000 per bus per year. For an agency the size of RTS, this is a reccurring expense of almost $1 million. Mechanisms that reduce this cost even by a small fraction would allow agencies to operate hundreds to thousands of more service hours per year.

**Table 3-1. RTS safety history**

| Year | Collisions | Fatal & Injuries | | | | | Vehicle Revenue Hours (million hr) |
|---|---|---|---|---|---|---|---|
| | | Passenger & Employee | Bicyclist | Pedestrian | Other | Total | |
| **RTS** | | | | | | | |
| **2015** | 10 | 6 | 1 | 2 | 4 | 13 | 0.355 |
| **2016** | 7 | 10 | 2 | 0 | 2 | 17 | 0.340 |
| **2017** | 14 | 10 | 0 | 1 | 6 | 17 | 0.341 |
| **2018** | 20 | 19 | 0 | 0 | 7 | 26 | 0.358 |
| **2019** | 13 | 6 | 0 | 0 | 4 | 10 | 0.358 |
| **Avg** | 12.8 | 10.2 | 0.6 | 0.6 | 4.6 | 16.0 | 0.347 |
| **N*** | 36.94 | 29.43 | 1.73 | 1.73 | 13.27 | 46.17 | ---- |
| **National** | | | | | | | |
| **2015** | 5,618 | 7,074 | 113 | 343 | 2192 | 9,722 | 215.3 |
| **2016** | 5,847 | 6,820 | 93 | 310 | 2386 | 9,610 | 219.8 |
| **2017** | 6,022 | 6,322 | 134 | 290 | 2384 | 9,130 | 222.1 |
| **2018** | 6,126 | 6,394 | 110 | 284 | 2278 | 9,066 | 223.2 |
| **2019** | 5,606 | 5,797 | 126 | 256 | 1940 | 8,119 | 223.2 |
| **Avg** | 5,844 | 6,482 | 115.2 | 296.6 | 2236 | 9,129 | 220.7 |
| **N*** | 26.48 | 29.37 | 0.52 | 1.34 | 10.13 | 41.36 | ---- |

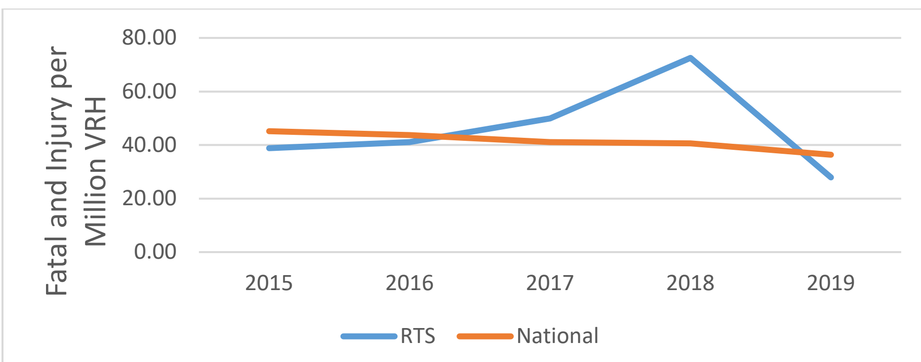



**Figure 3-1 – Nationwide and RTS fatal + injury rate**

This section will provide the following: (1) pedestrian and bicycle crash data in Gainesville; (2) RTS routes and ridership statistics; and (3) Pedestrian activity around campus. In addition, Appendix A shows the RTS bus route maps.

## 3.1 Pedestrian and Bicycle Crash Data Review

Signal Four Analytics crash data from 2013–2017 were reviewed. The crash data revealed that there were about 1,002 total crashes involving pedestrians and bicyclists in the five-year period, including 135 fatal and serious injury crashes (Figure 3-4). The crash trend indicates a reduction in overall pedestrian and bicycle crashes in 2014 (174) and 2015 (179); however, there was a rising trend with increased crashes in 2016 (226) and 2017 (219) which is consistent with the national trend. Upon further screening, the map below shows the crash numbers by segment and intersection, which helped correlate the historical high crash locations with RTS bus routes.

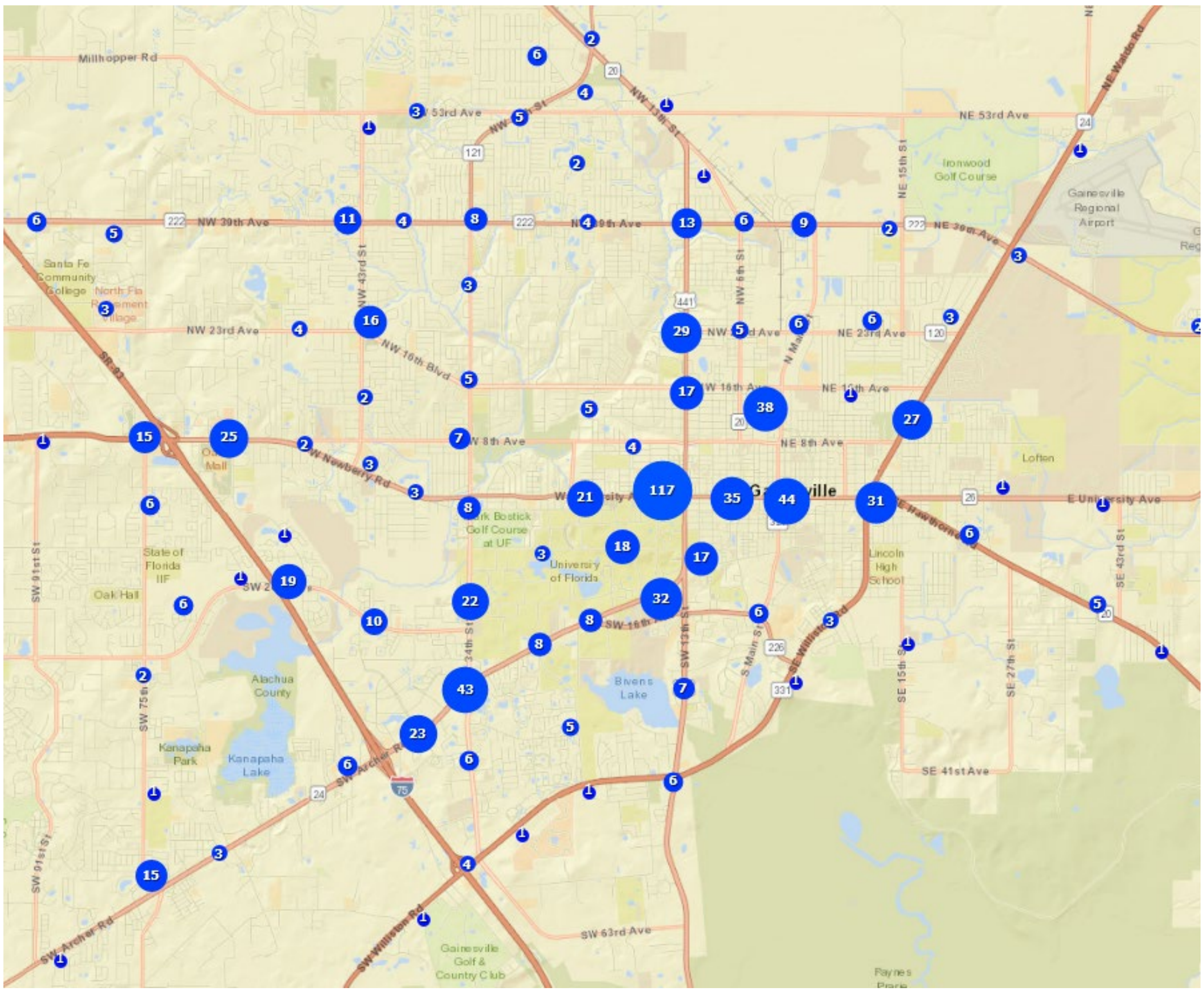



**Figure 3-2 – Pedestrian and bicycle crash numbers by segment and intersection**

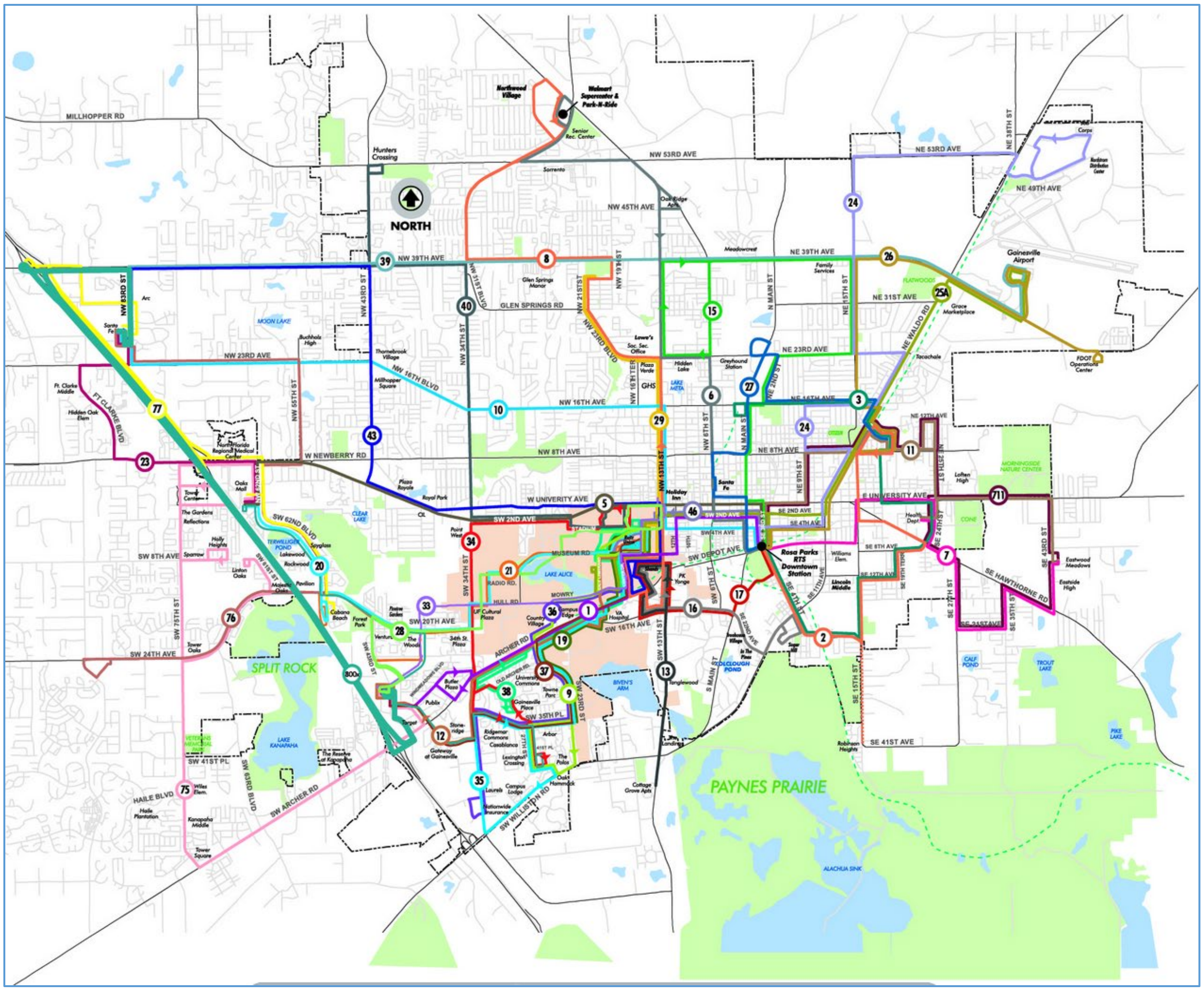



**Figure 3-3 – Gainesville RTS weekday routes for spring 2019**

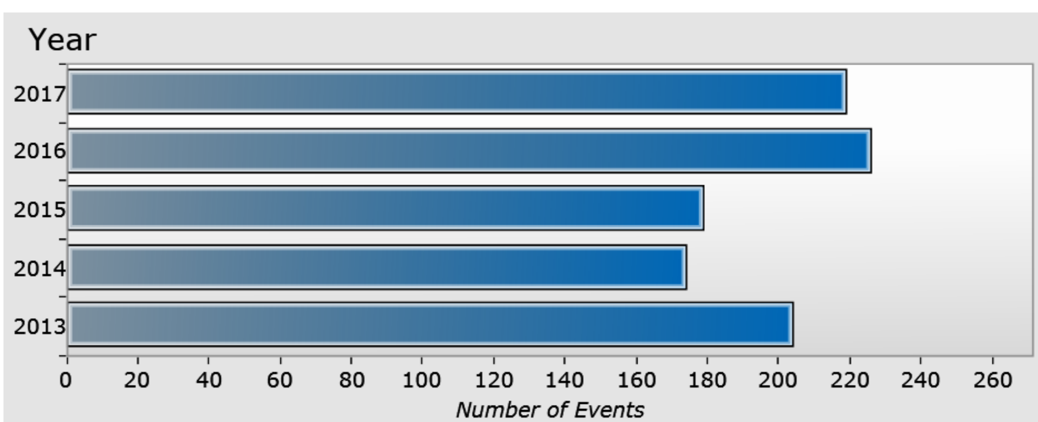



**Figure 3-4 – Number of pedestrian and bicycle incidents, 2013–2017**

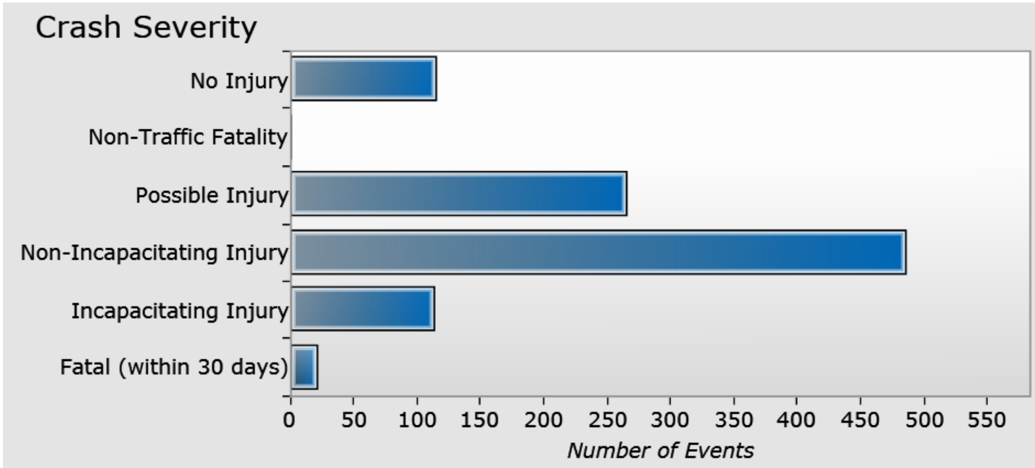



**Figure 3-5 – Number of pedestrian and bicycle incidents by severity**

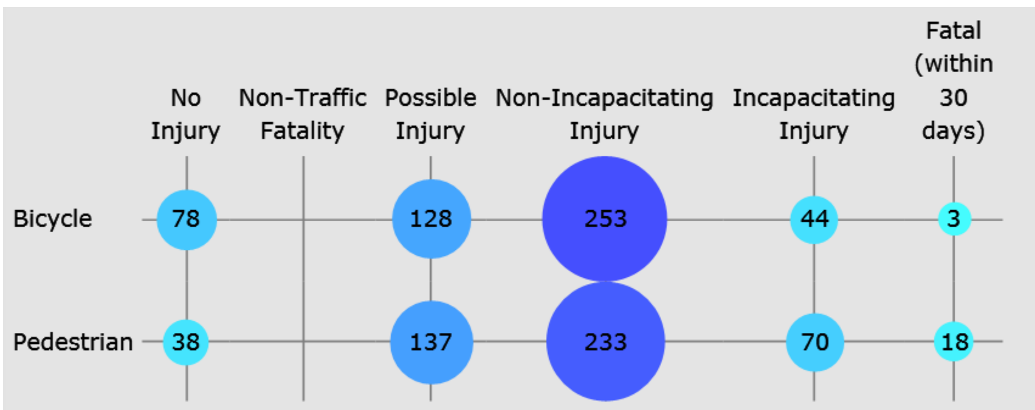



**Figure 3-6 – Severity of crashes by mode of transport**

A previous study pooled the pedestrian and bicycle crashes in Gainesville from 2009 to 2011 (Figure 3-5). A total of 281 pedestrian crashes with injuries or fatalities were identified at the intersection of 34th Street and Archer Road (Figure 3-2, marked “43”). A total of 246 injuries or fatalities were identified at all other major intersections. This confirms areas of increased pedestrian and bicycle incidents from Figure 3-2 as the main corridors surrounding the UF campus including W University Ave, SW 13th St, SW 34th Ave, Archer Rd, and SW 20th Ave.

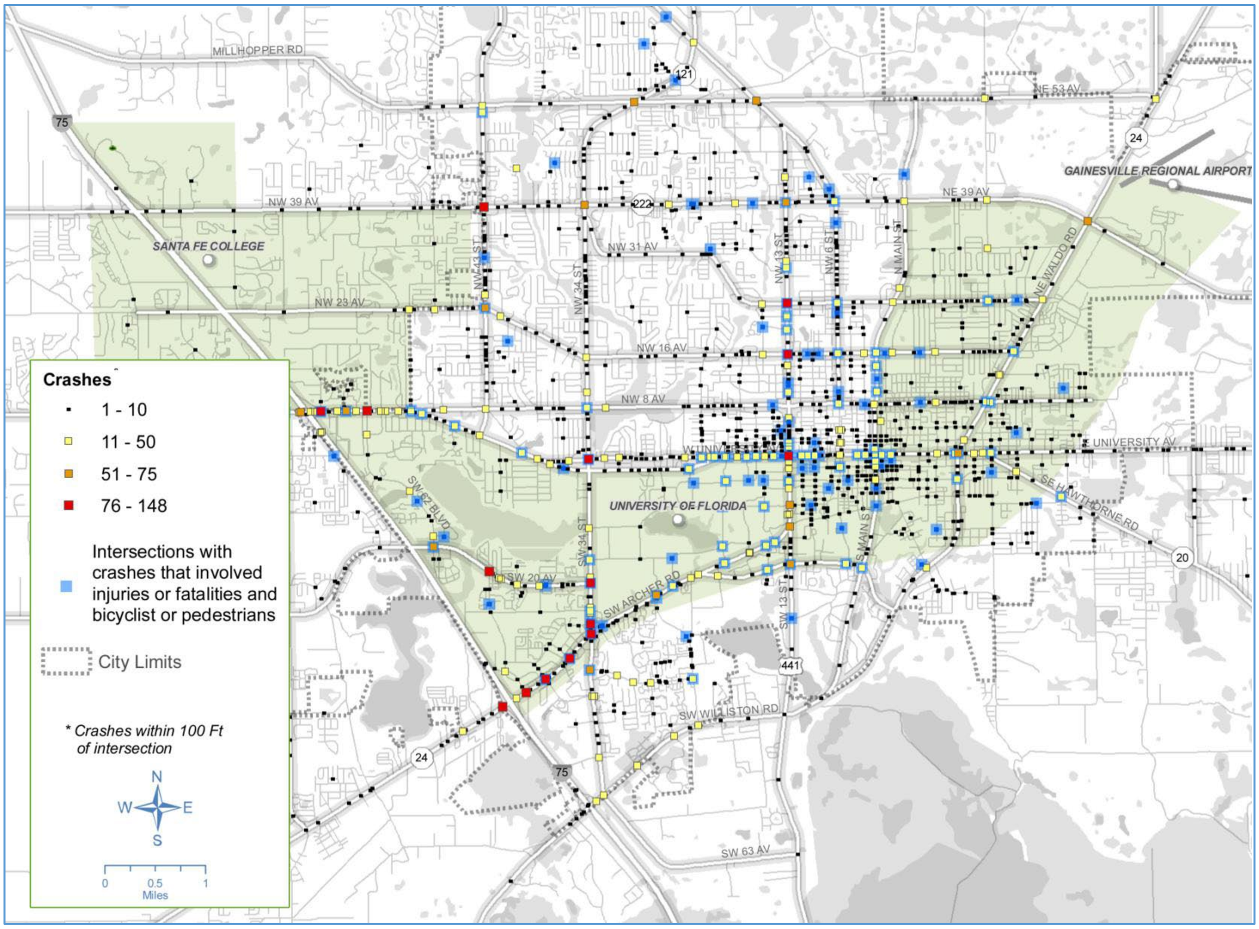



**Figure 3-7 – Crashes involving pedestrians and pedestrian injuries and fatalities by intersection, 2009–2011**

## 3.2 RTS routes and Ridership Statistics

This section summarizes the RTS bus routes that circulate or run through the main campus area. Maps of all the campus circulator routes are found in Appendix A. The ridership statistics for these campus routes from 2014 to 2016 fiscal years are shown in Table 3-3.

**Table 3-2. Three-year average ridership for campus circulator routes**

| Route | FY 2016 Pass | FY 2015 Pass | FY 2014 Pass | Total | Avg FY Pass |
|---|---|---|---|---|---|
| 117 | 258,656 | 206,497 | 138,507 | 603,660 | **201,220** |
| 118 | 325,535 | 329,518 | 308,259 | 963,312 | **321,104** |
| 119 | 56,048 | 61,825 | 68,506 | 186,379 | **62,126** |
| 120 | 209,557 | 254,709 | 271,974 | 736,240 | **245,413** |
| 121 | 51,771 | 59,843 | 76,497 | 188,111 | **62,704** |
| 122 | 39,123 | 40,044 | 46,581 | 125,748 | **41,916** |
| 125 | 255,822 | 273,049 | 277,704 | 806,575 | **268,858** |
| 126 | 84,990 | 115,920 | 82,173 | 283,083 | **94,361** |
| 127 | 190,262 | 189,837 | 192,638 | 572,737 | **190,912** |
| 128 | 839 | 858 | 1,124 | 2,821 | **940** |
| 129 | 15,955 | 4,876 | - | 20,831 | **10,416** |

In addition to the campus circulator routes, selected city routes that border or intersect campus were considered for instrumentation. Maps of these city routes are also provided in Appendix A. The ridership statistics for these selected city routes from the 2014 to 2016 fiscal years are shown in Table 3-4.

**Table 3-3. Three-year average ridership for selected city routes**

| Route | FY 2016 Pass | FY 2015 Pass | FY 2014 Pass | Total | Avg FY Pass |
|---|---|---|---|---|---|
| 1 | 651,637 | 659,422 | 695,574 | 2,006,633 | **668,878** |
| 5 | 436,851 | 466,131 | 510,084 | 1,413,066 | **471,022** |
| 8 | 290,526 | 312,035 | 339,621 | 942,182 | **314,061** |
| 9 | 512,119 | 622,136 | 662,457 | 1,796,712 | **598,904** |
| 10 | 113,046 | 130,394 | 150,725 | 394,165 | **131,388** |
| 12 | 704,775 | 755,489 | 824,110 | 2,284,374 | **761,458** |
| 13 | 334,563 | 355,597 | 406,937 | 1,097,097 | **365,699** |
| 20 | 1,226,333 | 1,124,947 | 1,176,507 | 3,527,787 | **1,175,929** |
| 34 | 277,852 | 273,582 | 309,607 | 861,041 | **287,014** |
| 38 | 547,824 | 527,807 | 483,332 | 1,558,963 | **519,654** |
| 43 | 197,433 | 215,228 | 215,058 | 627,719 | **209,240** |

The selected city routes were considered for their interaction with campus, but also for their overlap with the four high volume corridors surrounding campus. Figure 3-8 shows the crash frequency for the roadways surrounding the UF campus. Within the corridor, a total number of 12,260 crashes were identified in the three-year period along all of the major roadways, including Archer Rd, SW 20th Ave, SW 34th St, SW 13th Street, and University Ave.

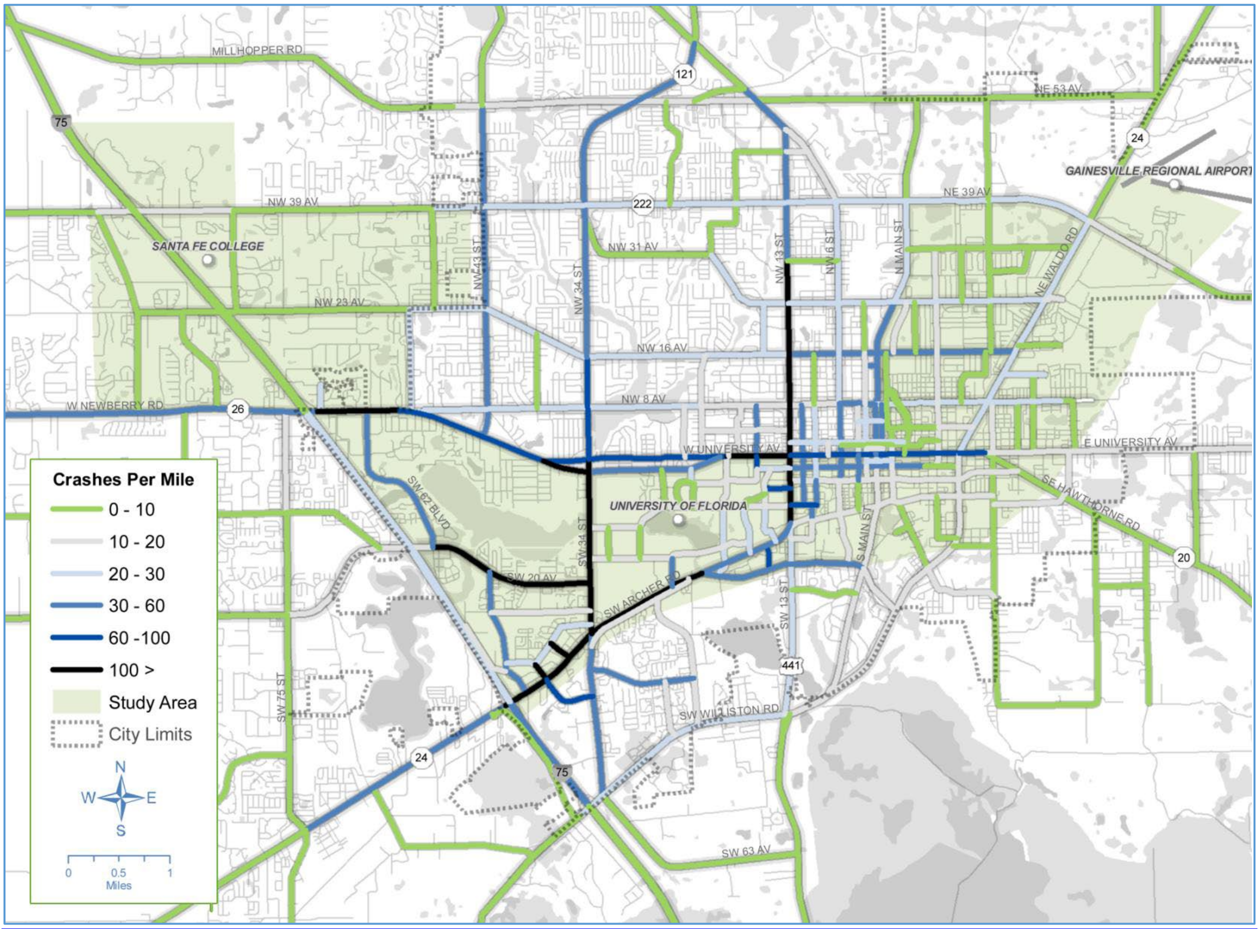



**Figure 3-8 – Vehicle crashes per road segment mile, 2009–2011**

## 3.3 Pedestrian Activity on and Near Campus

The UF campus experiences large volumes of pedestrian and bicycle traffic. There are currently no data to capture historical pedestrian and bicycle traffic in and around the campus. However, there are pedestrian areas that are known for high pedestrian traffic. As the campus sidewalks intersect surrounding roadways, the pedestrians and bicyclists often display erratic behavior such as jaywalking and crossing signalized intersections on red phases. The goal of this section is to identify high traffic areas of pedestrians and bicycles. These areas often coincide with the heart of the UF campus.

Figure 3-9 identifies mid-block crossings that experience high pedestrian volume on the University of Florida campus. Buses that interact with these crossings are likely to experience a higher volume of pedestrian interactions than other buses. Other mid-block crossings are shown on the map. These crossings are lower volume in terms of pedestrian movements.

In Figure 3-9, two roads that border the campus area are highlighted: SW 13th Ave and University Ave. W University Ave serves as a barrier between the campus and dining and recreation areas. As this is a low speed corridor, this area experiences a large amount of jaywalking. Similarly, SW 13th Ave serves as a barrier between the campus and student housing. This roadway experiences jaywalking and surges of pedestrian traffic during the school day. Buses that traverse these roadways in addition to the campus area are likely to experience unexpected pedestrian interactions.

In order to maximize the exposure of buses equipped with the Shield+ system, routes must be selected that overlap with these high traffic areas. Table 3-5 shows the identified campus routes and the number of high traffic mid-block crossings that each route coincides with.

**Table 3-4. Summary of high volume pedestrian interaction**

| RTS Bus Route | High Exposure Crossings | Additional Crossings | High Volume Arterial |
|---|---|---|---|
| **117** | 1 | 8 | 0 |
| **118** | 3 | 16 | 1 |
| **119** | 2 | 16 | 1 |
| **120** | 3 | 13 | 0 |
| **121** | 3 | 10 | 1 |
| **122** | 2 | 9 | 0 |
| **125** | 4 | 20 | 0 |
| **126** | 4 | 21 | 0 |
| **127** | 2 | 4 | 0 |

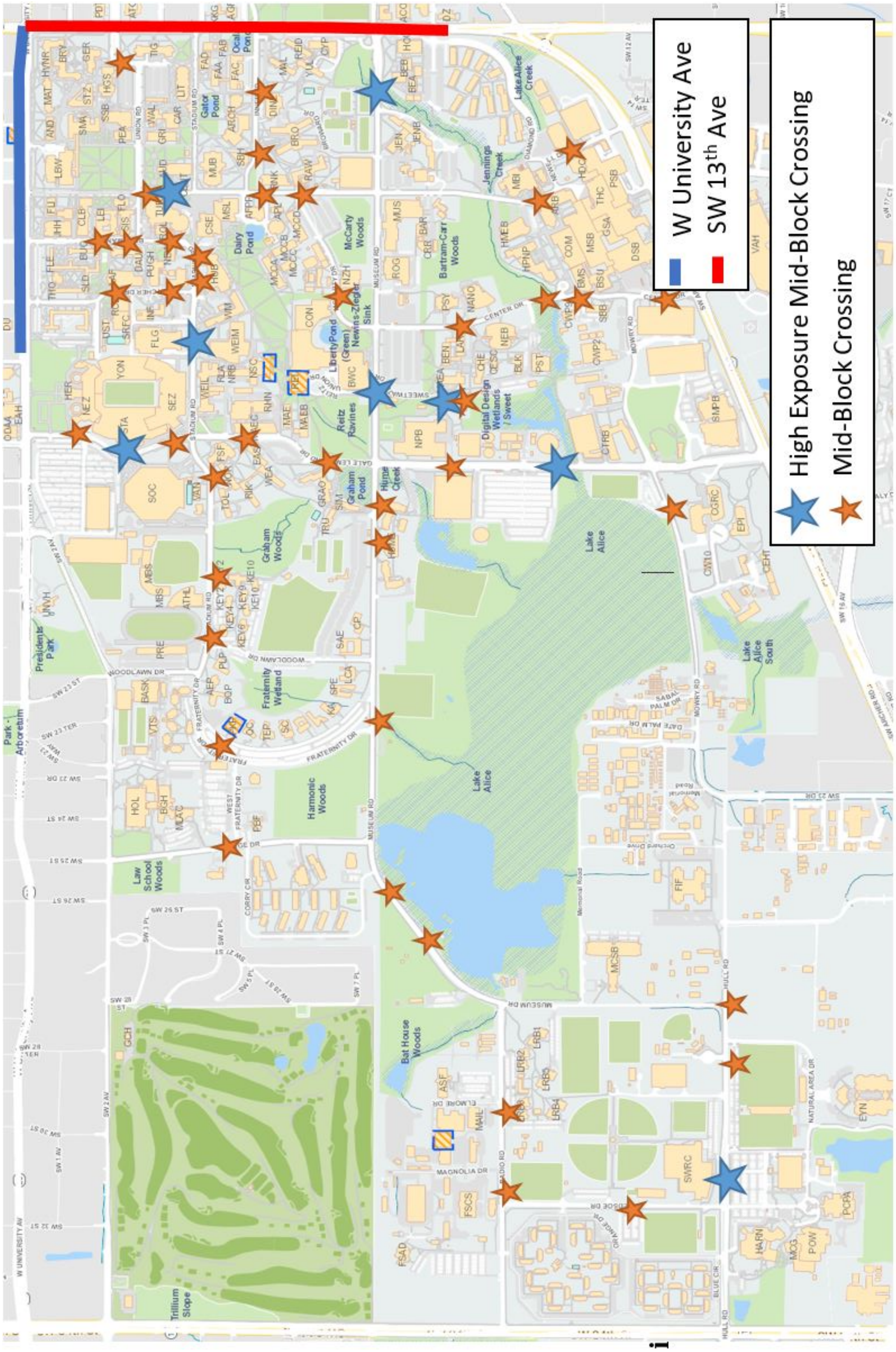



**Figure 3-9 – High activity pedestrian corridors bordering campus**

# Chapter 4 – Mobileye System

## 4.1 Introduction to the Mobileye Shield+ System

The following section summarizes timelines for the installation of the Shield+ system and driver training. In addition, Appendix C shows the Mobileye Shield+ installation guide, Appendix D shows the photo catalogue of the Shield+ installation. Appendix E shows the executed contract between UF and Rosco and Appendix F shows the memorandum of understanding executed between UF and the City of Gainesville. Appendix G provides information regarding the driver training materials.

The installation of the Mobileye Shield+ system required coordination between the system vendor (Rosco), UF, and the Gainesville Regional Transit System (RTS). The scope of the project required the installation on a minimum of 10 RTS transit buses to operate on UF's campus circulator routes and provide the framework for exploring the novel aspects of the deployment. Not only did this equipment operate in an area with unprecedented multimodal activity, the study was also the first of its kind to attempt to determine whether an agency can develop beneficial products from limited ADAS deployment.

The Mobileye Shield+ system includes three driver alert displays (Figure 4-1). The center-mounted display provides alerts for speed limits, lane departure, forward collision, and headway monitoring. The two side-mounted displays produce a solid amber indication to alert drivers to pedestrian or bicycle presence around the bus, and a red blinking alert is accompanied by a beeping sound to alert the driver of an imminent collision. The system consists of two interior-mounted smart sensor cameras and two exterior housings with smart sensor cameras. A telematics system is able to log the location and time of a triggered warning.

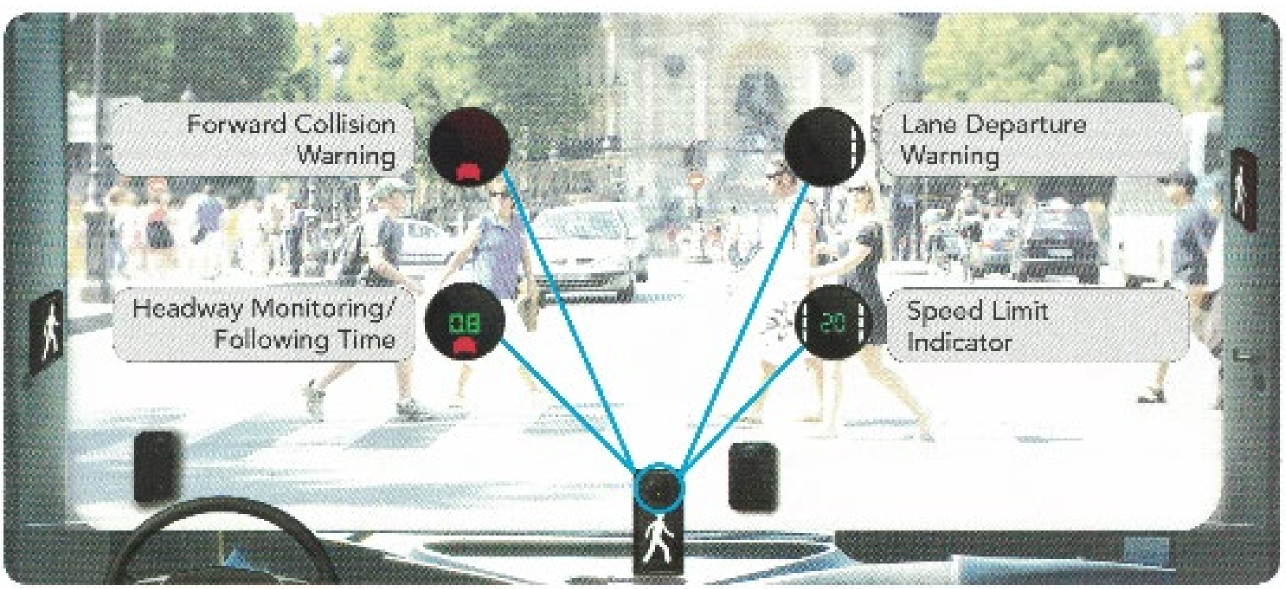



**Figure 4-1 – View of smart sensors and driver displays**

The installation of the Shield+ system required contracts between Rosco Trucking LLC and UF and between UF and the City of Gainesville. Negotiations of both contracts took longer than anticipated due to issues regarding data ownership and liability. Both of these contracts were executed on December 12, 2018. This delay required a no-cost extension amendment to the deliverable timeline. The timeline involving contract execution and installation is shown in Figure 4-2.

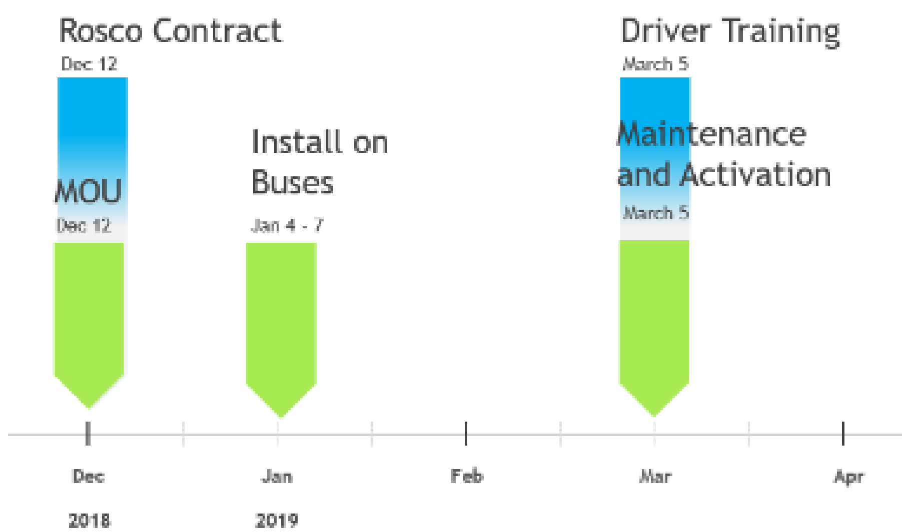



**Figure 4-2 – Schedule of installation and activation**

UF submitted procurement documents, and the system was installed on 10 buses during January 4–7, 2019. The buses and associated routes are shown in Table 4-1. Upon completion of installation on the 10 buses (manufactured by Gillig LLC, Livermore, CA), there was an observed issue involving a speed-sensing challenge with the 2018 model years. Rosco had been installed previously on 2018 Gilligs without issue; however, the RTS buses required an increase in baud rate from 250K to 500K. Rosco coordinated with Mobileye to create a new software profile that reads the speed sensor on these Gilligs and completes the software configuration on these four 2018 model buses.

**Table 4-1. Bus information for the installed Shield+ system**

| Bus No. | Manufacturer | Model Year | Route |
|---|---|---|---|
| 701 | Gillig | 2007 | 1 |
| 703 | Gillig | 2007 | 1 |
| 1016 | Gillig | 2010 | 16 |
| 1017 | Gillig | 2010 | 17 |
| 1301 | Gillig | 2013 | 125 |
| 1302 | Gillig | 2013 | 117 |
| 1803 | Gillig | 2018 | 8 |
| 1804 | Gillig | 2018 | 8 |
| 1805 | Gillig | 2018 | Floating |
| 1806 | Gillig | 2018 | 8 |

Following the installation of equipment on the buses, the research team was trained on the usage of the Ituran telematics system (Figure 4-3). The Ituran Web interface is able to create reports about warnings generated by the system, such as pedestrian collision and headway monitoring warnings. A full list of warnings is provided in Table 4-2. The Web application can also generate heatmaps to identify increased areas of pedestrian interaction (Figure 4-4) and a street level view (Figure 4-5) of logged warnings. After initially evaluating the data that are being reported, it was determined that there was an issue with telematics reporting on buses 1804 and 1017. There was also an identified issue with the center display on bus 1805. Both issues were resolved by a visit from Rosco technicians on March 5, 2019.

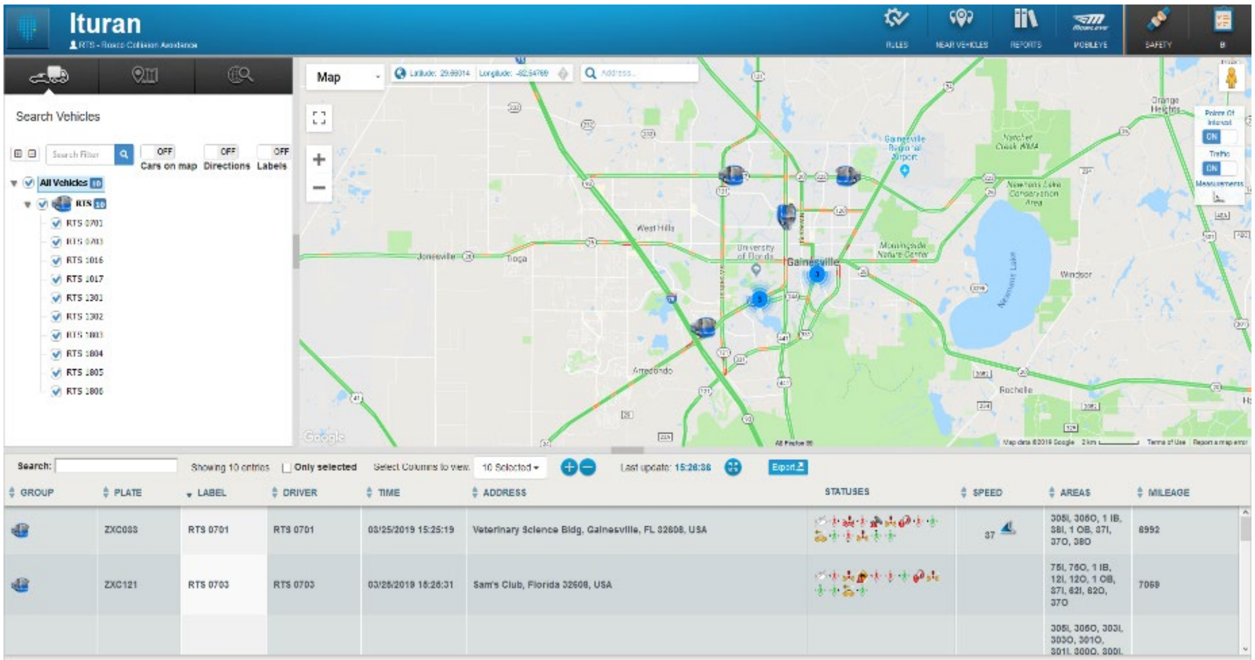



**Figure 4-3 – Screenshot of the Ituran Web interface showing active buses**

**Table 4-2. Warnings generated and logged by the Mobileye Shield and telematics system**

| Warning Code | Description |
|---|---|
| ME – Forward Collision Warning | Master camera inside front of bus detecting forward collision with vehicles in front of bus; output is in EyeWatch |
| ME – Headway Monitoring | Master camera inside front of bus monitoring the TTC (Time to Collison) with vehicles in front of bus; output is in EyeWatch |
| ME – Pedestrian in Range Warning PDZ | Master camera inside front of bus for pedestrian or bicyclist detection resulting in yellow flash of pedestrian display in center of bus |
| ME – Pedestrian Collision Warning PCW | Master camera inside front of bus for pedestrian or cyclist alert resulting in red flash of pedestrian display and audio alert in center of bus |
| PDZ – LF | Left front corner camera inside front of bus for pedestrian or cyclist alert resulting in red flash of left pedestrian display and audio alert all on A-pillar |

**Table 4-2, continued**

| Warning Code | Description |
| --- | --- |
| PDZ – LF | Left front corner camera inside front of bus for pedestrian or cyclist alert resulting in red flash of left pedestrian display and audio alert all on A-pillar |
| PCW – LF | Left front corner camera inside front of bus for pedestrian or cyclist alert resulting in red flash of left pedestrian display and audio alert all on A-pillar |
| PDZ – L | Left rear camera outside of bus for pedestrian or cyclist detection on left side resulting in yellow flash of left pedestrian display on A-pillar |
| PCW – LR | Left rear camera outside of bus for pedestrian or cyclist alert on left side resulting in red flash of left pedestrian display and audio all on A-pillar |
| PDZ – R | Right rear camera outside of bus for pedestrian or cyclist detection on right side resulting in yellow flash of right pedestrian display on right side |
| PCW – RR | Right rear camera outside of bus for pedestrian or cyclist alert on right side resulting in red flash of right pedestrian display and audio on right side |

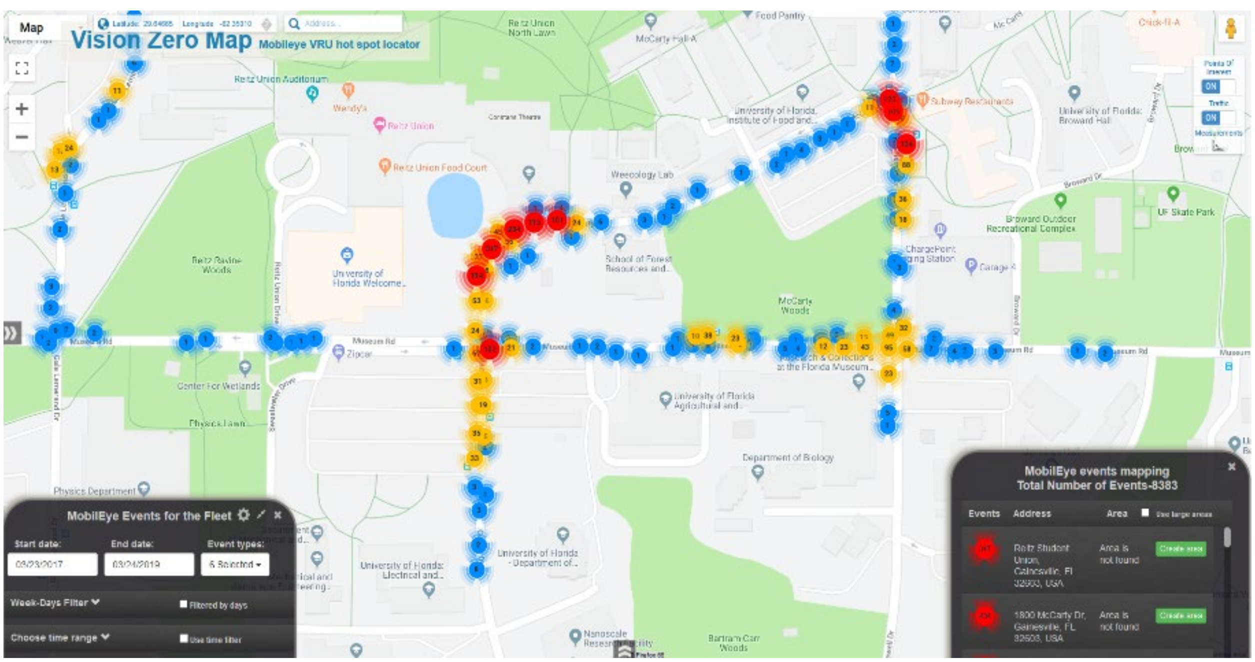



**Figure 4-4 – Screenshot of the Ituran Web interface showing a heatmap of generated warnings**


**Figure 4-5 – Screenshot of the Ituran Web interface showing a street view of logged pedestrian warnings**

The buses ran in stealth mode to gather baseline data for normal operation without the activating the system readouts. The system was actively logging warnings, but the driver did not receive any alerts on the displays nor interact with the system. The driver training was scheduled to occur the same day maintenance was performed on the system on March 5, 2019. The training involved members of Rosco's team traveling to Gainesville to train experienced drivers and fleet managers. These RTS employees were trained in operation of the system through in-vehicle demonstrations and PowerPoint presentations.

In addition to the Ituran Web interface, the data containing information about pedestrian warnings were stored by UF. The raw data stream was fed to UF through a TCP connection and loaded into an Amazon Web server. UF can control the access credentials, which allows the research team to restrict who can access the data. The research team stored historical bus route schedules, anonymized driver information, and warning information.

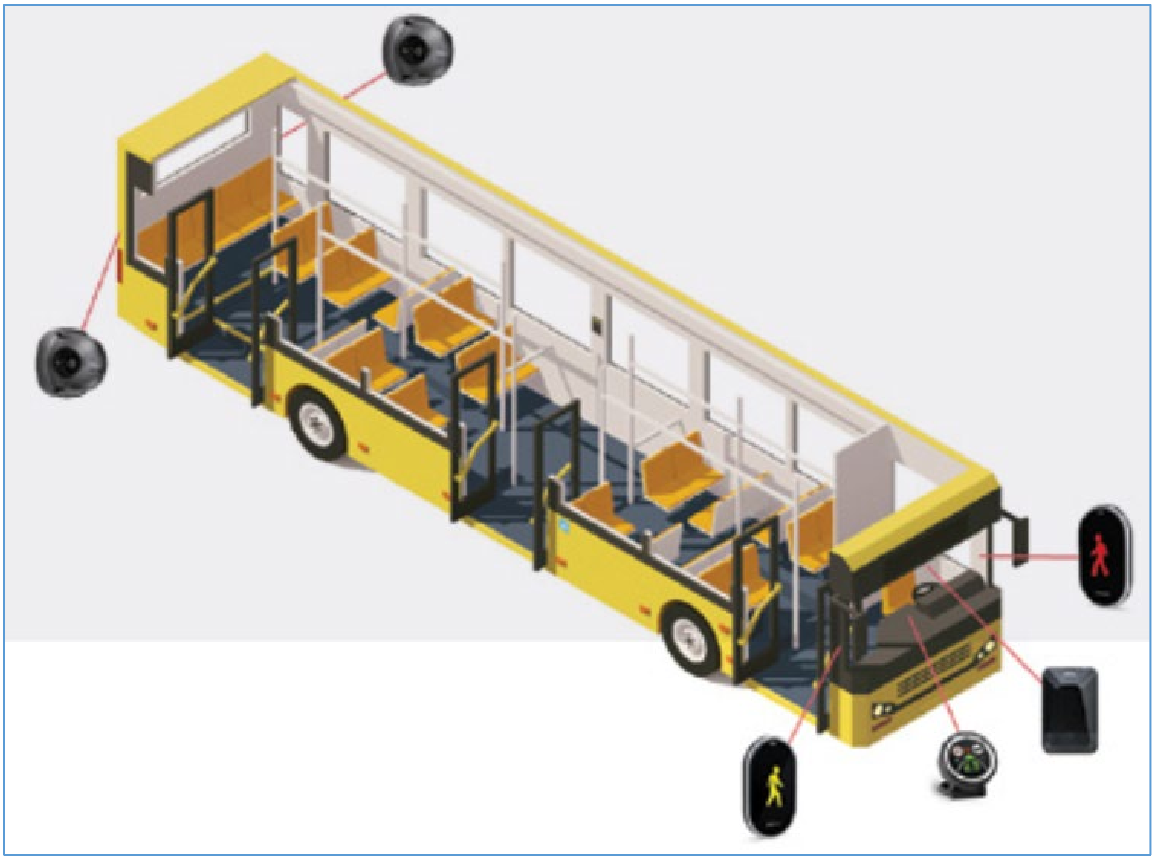


**Figure 4-6 – Mobileye Shield+ cameras and alert displays (Image: Mobileye)**

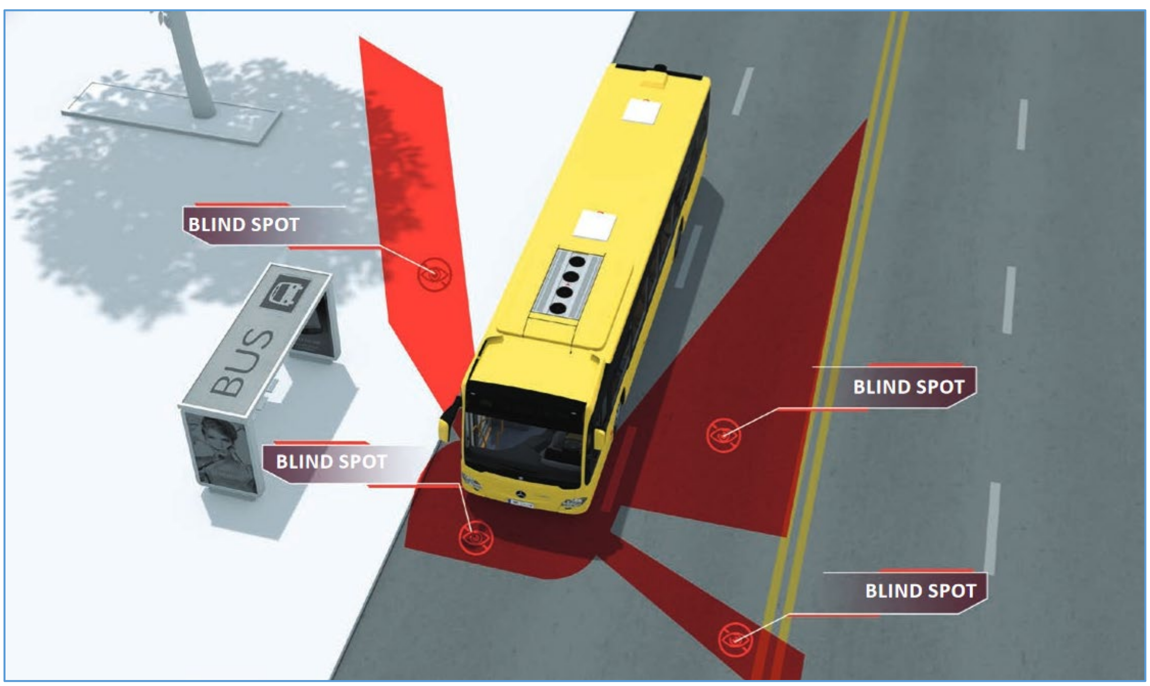



**Figure 4-7 – Bus driver blind spots (Image: Mobileye)**

The center-mounted display provides alerts for speed limits, lane departure, forward collision, and headway monitoring. The two side-mounted displays produce a solid amber indication to alert drivers of pedestrian or bicycle presence around the bus, and a red blinking alert is accompanied by a beeping sound to alert the driver of an imminent collision; as shown in Figure 4-8. The system consists of two interior-mounted smart sensor cameras and two exterior housings with smart sensor cameras. A telematics system is able to log the location and time of a triggered warning.


**Figure 4-8 – Mobileye alert displays**

In addition to the installation of the units, UF coordinated with Mobileye and Gainesville RTS to conduct driver training sessions to familiarize drivers with the system display messages and warnings. The system ran for two months in stealth mode to obtain additional baseline data. After this initial period, the units were activated for use by RTS drivers.

Ten bus routes were recommended to RTS. However, the routes are assigned based on the community needs, and the research team had no control over the assignments. Although the buses were assigned to different routes, the data generated by randomizing the buses and the routes actually supported statistical significance by avoiding any route familiarity bias that may occur by a driver navigating the same route every day for prolonged period. This approach helps the robustness of the study to quantify the benefits of the system as opposed to driver familiarity with the routes.

## 4.2 Mobileye Alarms

Mobileye Shield+ in intended to support better detection of pedestrians and bicycles. The system includes four cameras (one center, two side, and one side front bumper) to detect vehicular and pedestrian conflicts. Some of the Mobileye Shield+ alerts in the focus of this study are as follows:

Pedestrian alerts:

- Visual only - Pedestrian detections resulting in yellow indicator illumination but no audible alerts (PDZs)
- Mobileye pedestrian collision warning forward (PCW)

Vehicle alerts:

- Urban forward collision warning (UFCW; speed 0 to 19 mph)
- Forward collision warning (FCW; speed > 19 mph)
- Headway warning (HWW)

Other alerts:

- Aggressive braking (AggBrk)

Some alerts that were not in the focus of this study:

- Lane departure warning (Mobileye LDW)
- Intelligent high-beam control (IHC)
- Speed limit indicator (SLI)
- Traffic sign recognition
- Exceeded speed limits
- Total audible alerts
- Total audible alerts related to forward facing events

Alerts are delivered to the driver through three driver interface displays and one junction unit. One of the side indicators shows a yellow light when the time to collision with a pedestrian or bicycle is less than 2.5 seconds. If the time to collision is less than 1 second, the other side indicator shows a red light along with a sound alarm. Hadi et al. (2019), indicated that the Mobileye Shield+ PCW alert only is operational during the day. The center indicator provides the driver with FCW, HWW, LDW, and SLI.

## 4.3 Ituran Telematics

The Mobileye alarms are accessible for review and download through Ituran telematics. The alarms are geolocated and timestamped. Figures 4-9 to 4-16 show different features and tabs of the Ituran Telematics website. Figure 4-9 shows the interface of the website. Figures 4-10 and 4-11 show the options for reporting alerts and the options of the message report tab, respectively. Figure 4-12 shows generated reports while Figure 4-13 depicts the downloaded spreadsheet from the generated report.

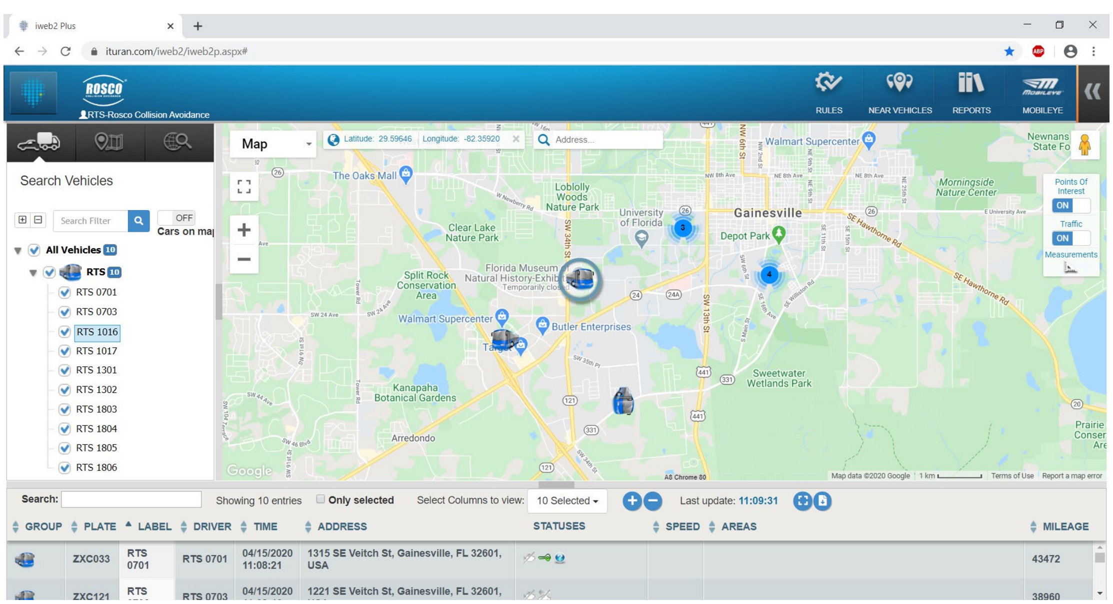



**Figure 4-9 – Ituran Telematic website interface**

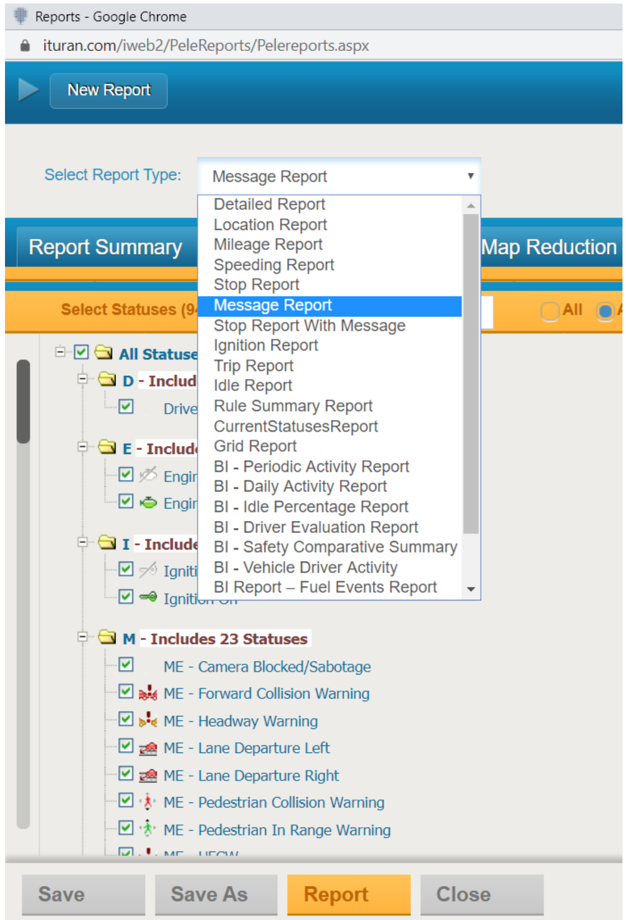



**Figure 4-10 – Ituran telematics website report types**

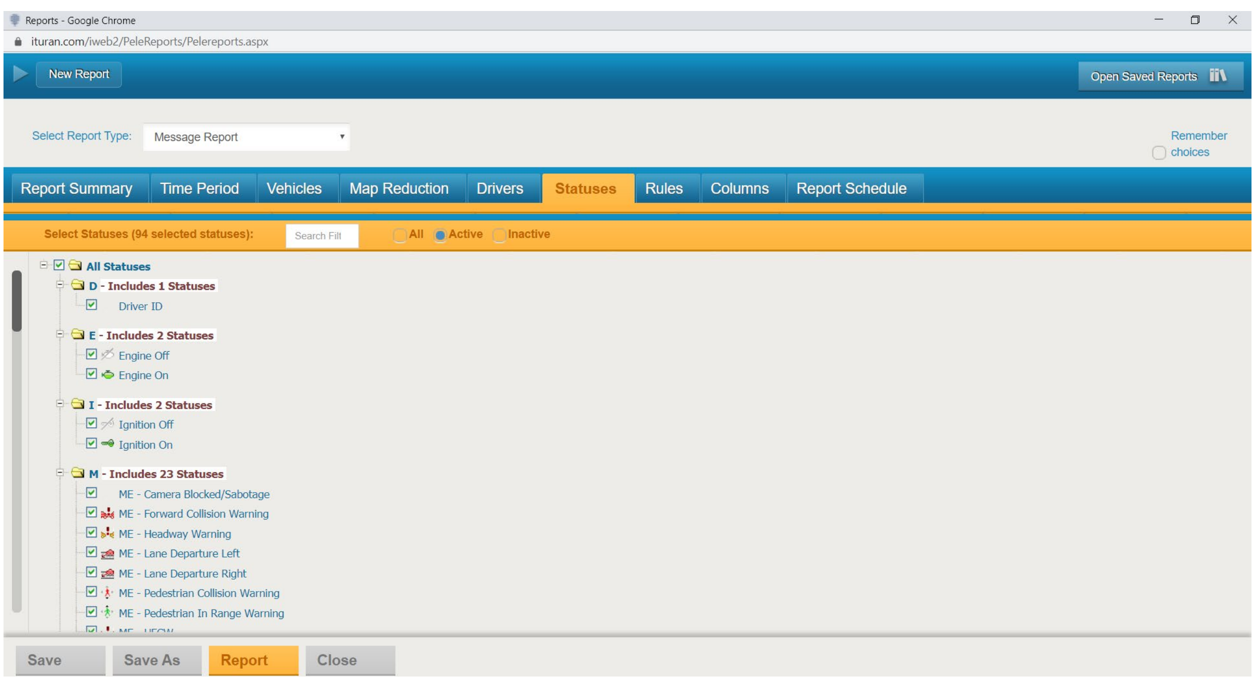



**Figure 4-11 – Ituran telematics website message reports options to download alerts**

Reports - Google Chrome
ituran.com/iweb2/PeleReports/Pelereports.aspx

New Report

**Message Report**

Description: **unnamed Message Report**
Customer: **- Rosco Collision Avoidance**, User: **RTS**
Number of selected vehicles: **10 (information exists for 6 of 10 vehicles selected)**
Time Period: **04/15/2020 00:00:00 (Today)**
Total Records: **185**

Show 250 entries | Search: | Default View

| Loc Time | Vehicle Name | Heading | Odometer | Address | Speed | Status Name | Latitude | Longitude |
|---|---|---|---|---|---|---|---|---|
| 04/15/2020 11:14:14 | RTS 0703 | - | 38960.284 | 1221 SE Veitch St, Gainesville, FL 32601, USA | - | PDZ-R | 29.63929 | -82.32406 |
| 04/15/2020 07:25:15 | RTS 1016 | E | 46280.411 | 330 SW 42nd St, Gainesville, FL 32608, USA | 12 | PDZ-R | 29.62500 | -82.38731 |
| 04/15/2020 07:30:00 | RTS 1016 | E | 46281.654 | 3743 Hull Rd, Gainesville, FL 32607, USA | 5 | PDZ-R | 29.63735 | -82.37790 |
| 04/15/2020 07:39:06 | RTS 1016 | E | 46283.518 | Shands Visitor Parking, Gainesville, FL 32603, USA | 21 | PDZ-R | 29.63957 | -82.34725 |
| 04/15/2020 07:47:45 | RTS 1016 | W | 46285.319 | 1478 Union Rd, Gainesville, FL 32611, USA | 6 | PDZ-R | 29.64979 | -82.34174 |
| 04/15/2020 07:53:06 | RTS 1016 | - | 46285.814 | Frazier Rogers Hall, Gainesville, FL 32603, USA | - | PDZ-LR | 29.64492 | -82.34509 |
| 04/15/2020 07:59:14 | RTS 1016 | W | 46286.435 | Wilmot Gardens, Gainesville, FL 32603, USA | 19 | PDZ-R | 29.63970 | -82.34863 |
| 04/15/2020 08:40:07 | RTS 1016 | - | 46292.091 | The Ridge @ SW 38th TER southbound, Florida 32607, USA | - | PDZ-R | 29.63142 | -82.38093 |
| 04/15/2020 09:11:57 | RTS 1016 | W | 46298.368 | Mycology Laboratory, Gainesville, FL 32608, USA | 7 | PDZ-R | 29.63765 | -82.36232 |
| 04/15/2020 09:46:57 | RTS 1016 | W | 46301.474 | Celebration Pointe At Regal Cinema 10, Florida 32608, USA | 7 | PDZ-R | 29.62298 | -82.39512 |
| 04/15/2020 09:50:18 | RTS 1016 | E | 46302.406 | 3100 SW 42 Way, Gainesville, FL 32608, USA | 9 | ME - Pedestrian In Range Warning | 29.62499 | -82.38836 |
| 04/15/2020 10:19:59 | RTS 1016 | W | 46308.805 | Lake Alice Conservation Area, Gainesville, FL 32608, USA | 19 | PDZ-R | 29.63850 | -82.35310 |
| 04/15/2020 10:35:39 | RTS 1016 | S | 46310.795 | Kensington Apartments Eastside, Florida 32607, USA | 19 | PDZ-R | 29.63369 | -82.38092 |

Showing 1 to 185 of 185 entries

First Previous 1 Next Last

Print | Export | Modify... | Playback | Close

**Figure 4-12 – Sample message report generated by Ituran telematics**

**Message Report**

Report Name: UFCW

Description: **Message Report, UFCW**
Customer: **- Rosco Collision Avoidance**, User: **RTS**
Number of selected vehicles: **7 (information exists for 7 of 7 vehicles selected)**
Time Period: **02/01/2019 00:00:00 - 02/28/2019 23:59:59**
Total Records: **14991**

| Loc Time | Vehicle Name | Heading | Address | Speed | Status Name | Latitude | Longitude |
|---|---|---|---|---|---|---|---|
| 02/01/2019 05:51:03 | RTS 0701 | S | 3330 SW Archer Rd, Gainesville, FL 32608, USA | 6 | ME - UFCW | 29.62734 | -82.372533 |
| 02/01/2019 06:32:28 | RTS 0701 | - | 3330 SW Archer Rd, Gainesville, FL 32608, USA | - | ME - UFCW | 29.627316 | -82.372183 |
| 02/01/2019 06:51:19 | RTS 0701 | S | 3330 SW Archer Rd, Gainesville, FL 32608, USA | 7 | ME - UFCW | 29.627463 | -82.37256 |
| 02/01/2019 06:51:21 | RTS 0701 | S | 3330 SW Archer Rd, Gainesville, FL 32608, USA | 6 | ME - UFCW | 29.62744 | -82.37256 |
| 02/01/2019 06:59:17 | RTS 0701 | N | Shands Hospital @ Dental Science Building, Gainesville, FL 32601, USA | 7 | ME - UFCW | 29.638868 | -82.346208 |
| 02/01/2019 06:59:20 | RTS 0701 | N | Shands Hospital @ Dental Science Building, Gainesville, FL 32601, USA | 5 | ME - UFCW | 29.638918 | -82.346208 |
| 02/01/2019 07:33:03 | RTS 0701 | W | Shands Medical Plaza, 2000 SW Archer Rd, Gainesville, FL 32608, USA | 7 | ME - UFCW | 29.637393 | -82.348645 |
| 02/01/2019 07:34:08 | RTS 0701 | - | SW Archer Rd, Gainesville, FL 32608, USA | - | ME - UFCW | 29.635575 | -82.353841 |
| 02/01/2019 07:35:46 | RTS 0701 | - | 3056 SW Archer Rd, Gainesville, FL 32608, USA | - | ME - UFCW | 29.632558 | -82.361358 |
| 02/01/2019 07:58:03 | RTS 0701 | S | 2814 SW 34th St, Gainesville, FL 32608, USA | 12 | ME - UFCW | 29.627806 | -82.372553 |

**Figure 4-13 – Sample downloaded report from Ituran telematics website to spreadsheet format**

As shown in Figure 4-14, Ituran provides heatmap of the alerts to show the spatial distribution of them. The last feature of Ituran to discuss is the Safety tab, that has various report types as shown in Figure 4-15. Figure 4-16 shows an example report generated by the Safety tab.

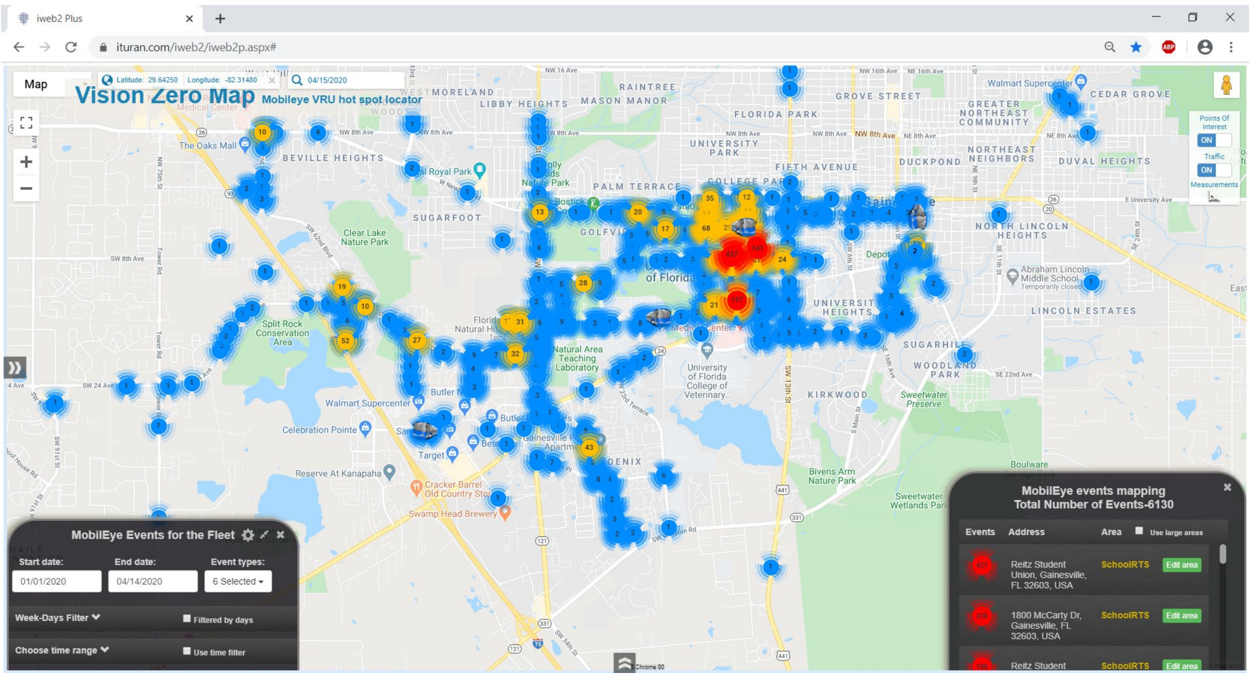



**Figure 4-14 – Screenshot of Ituran telematics website, showing a Mobileye alerts heartmap**

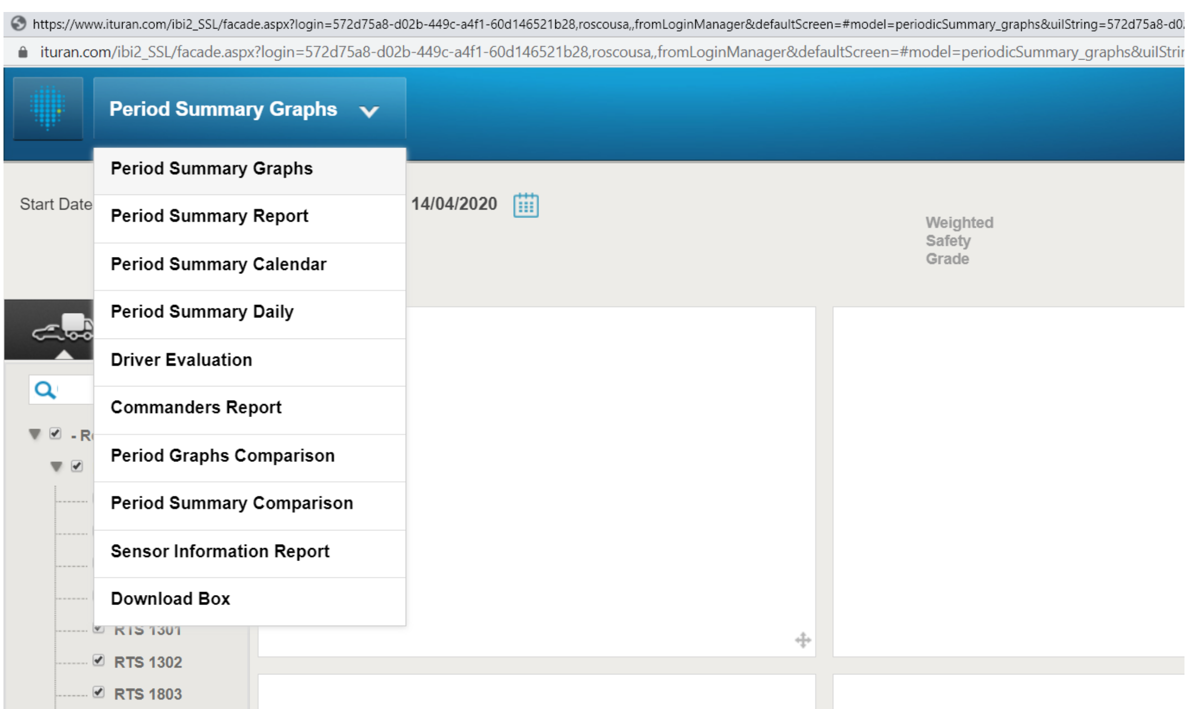
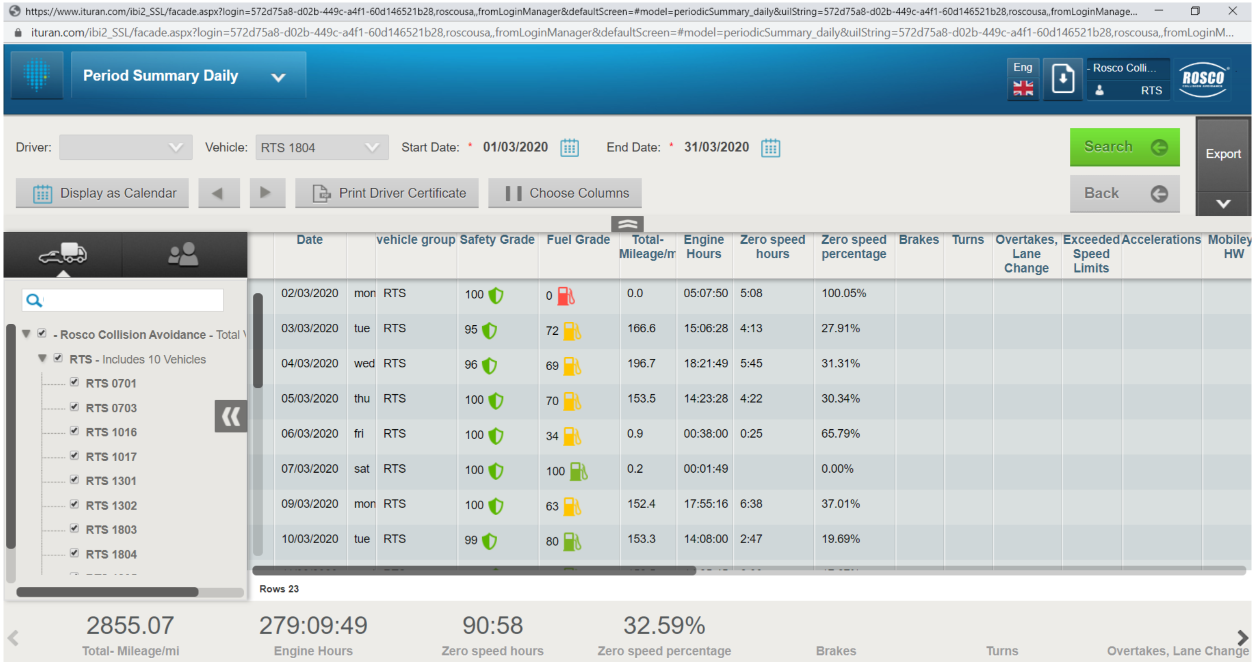



**Figure 4-15 – Options of the Ituran telematics Safety tab**




| Date | | vehicle group | Safety Grade | Fuel Grade | Total-Mileage/m | Engine Hours | Zero speed hours | Zero speed percentage | Brakes | Turns | Overtakes, Lane Change | Exceeded Speed Limits | Accelerations | Mobiley HW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 02/03/2020 | mon | RTS | 100 | 0 | 0.0 | 05:07:50 | 5:08 | 100.05% | | | | | | |
| 03/03/2020 | tue | RTS | 95 | 72 | 166.6 | 15:06:28 | 4:13 | 27.91% | | | | | | |
| 04/03/2020 | wed | RTS | 96 | 69 | 196.7 | 18:21:49 | 5:45 | 31.31% | | | | | | |
| 05/03/2020 | thu | RTS | 100 | 70 | 153.5 | 14:23:28 | 4:22 | 30.34% | | | | | | |
| 06/03/2020 | fri | RTS | 100 | 34 | 0.9 | 00:38:00 | 0:25 | 65.79% | | | | | | |
| 07/03/2020 | sat | RTS | 100 | 100 | 0.2 | 00:01:49 | | 0.00% | | | | | | |
| 09/03/2020 | mon | RTS | 100 | 63 | 152.4 | 17:55:16 | 6:38 | 37.01% | | | | | | |
| 10/03/2020 | tue | RTS | 99 | 80 | 153.3 | 14:08:00 | 2:47 | 19.69% | | | | | | |

**Figure 4-16 – Interan Safety tab, sample-generated report**

# Chapter 5 – Research Approach

## 5.1 Data Collection Plan

The Mobileye telematics system is a vehicle-based system that collects diverse alerts related to vehicular and pedestrian conflicts as well as other vehicle operational alerts such as engine on/off. Table 5-1 shows the list of alerts that are related to safety. Because the focus of this study is to quantify the safety performance of transit buses with respect to pedestrians, three main categories were selected for analysis: pedestrian-related alerts, rear-end alerts, and aggressive braking alerts. Some of the alerts had preconfigured thresholds with respect to speed and time to conflict (TTC).

**Table 5-1. Mobileye alerts**

| Alert | Thresholds | | |
|---|---|---|---|
| | **Abbreviation** | **Speed (mph)** | **TTC (sec)** |
| *These alerts were the focus of the project.* | | | |
| Pedestrian Detection | PDZ | | |
| Pedestrian Collision Warning | PCW | | <2 |
| Urban Forward Collision Warning | UFCW | <19 | <2.7 |
| Forward Collision Warning | FCW | >19 | <2.7 |
| Headway Warning | HWW | | <2.5 |
| Aggressive Braking | AggBrk | | |
| *The following alerts are available from Mobileye but were not used in our analysis.* | | | |
| Lane Departure Warning | LDW | | |
| Intelligent High-beam Control | IHC | | |
| Speed Limit Indicator | SLI | | |
| Traffic Sign Recognition | | | |
| Exceeded Speed Limits | | | |
| Total Audible alerts | | | |
| Total Audible alerts related to forward facing events | | | |

Table 5-2 shows data on the number of conflicts retrieved from the Ituran webpage (the interface provided by Mobileye for data extracted from the telematics system installed in each bus). Based on the number of alerts, it was inferred that the Shield+ system on three buses (1017, 1301, and 1804) had malfunctioned (highlighted in table). Bus 1301 reported no data for a year of the study period. Vehicle 1804 data were relatively low in comparison to other vehicles. For vehicle 1017, the data reported in Jan. and Feb. 2019 were lower than the rest of the year. Low or no data could bias the outcome; therefore, seven buses that had complete datasets were chosen for further analysis. Vehicle 1805 had only 1 alert in July 2019, and as such, that one month of data was eliminated from our analysis. These exceptions are highlighted in Table 5-2.

**Table 5-2. Monthly distribution of conflicts, retrieved through Ituran telematics**

| RTS Bus | 2019 | | | | | | | | | | | | 2020 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb |
| 0701 | 11,271 | 17,138 | 10,497 | 12,650 | 5,270 | 9,878 | 8,355 | 16,424 | 19,035 | 17,370 | 14,805 | 4,601 | 14,073 | 9,644 |
| 0703 | 6,800 | 12,894 | 12,271 | 11,530 | 9,254 | 6,428 | 6,220 | 7,317 | 13,222 | 10,367 | 7,970 | 4,926 | 9,864 | 10,544 |
| 1016 | 7,329 | 8,351 | 7,731 | 7,041 | 4,750 | 2,854 | 3,092 | 10,905 | 12,397 | 8,876 | 11,306 | 6,047 | 10,025 | 10,230 |
| 1017 | 701 | 48 | 7,336 | 8,294 | 3,665 | 4,533 | 4,613 | 8,521 | 10,658 | 12,041 | 8,127 | 3,521 | 10,735 | 8,244 |
| 1301 | 8,922 | 2,620 | | | | | | | | | | | | |
| 1302 | 21,437 | 20,685 | 2,281 | 13,826 | 7,078 | 4,786 | 5,080 | 14,920 | 21,663 | 23,044 | 16,438 | 5,365 | 15,980 | 18,936 |
| 1803 | 6,693 | 9,419 | 7,364 | 7,681 | 5,618 | 5,984 | 5,343 | 8,185 | 7,375 | 7,346 | 4,830 | 4,295 | 4,568 | 3,115 |
| 1804 | 785 | 643 | 30 | 41 | 29 | 36 | 23 | 16 | 8 | 14 | 3 | 37 | 170 | 132 |
| 1805 | 5,133 | 5,614 | 7,621 | 6,406 | 5,506 | 4,386 | 1 | 5,372 | 9,103 | 9,504 | 8,053 | 4,939 | 8,148 | 8,308 |
| 1806 | 5,239 | 6,317 | 5,137 | 7,103 | 4,713 | 4,613 | 3,292 | 7,860 | 8,667 | 7,561 | 5,741 | 2,011 | 6,737 | 8,318 |

As detailed in the previous task summary (Deliverable 2), ten bus routes were initially selected based on RTS input. However, the routes changed sporadically based on agency and community needs. As a result, the data generated by randomizing the buses and the routes supported statistical significance by avoided route familiarity bias that may have occurred if drivers navigated the same route daily for a prolonged period. The analysis in this study was twofold:

- First, an aggregate analysis was completed that included conflicts from all buses
- Second, a disaggregate route-based analysis was completed.

For each of the above, extensive data processing was needed, which is summarized in next section.

## 5.2 Data Collection and Processing

Data were collected for 422 days. Data from 7 of the 10 buses were included in the analysis. An FTP feed was set up to receive the daily log of all alert data. The data were processed to develop two structured databases: Mobileye alert data and route data. The following two subsections explain the process of making the structured databases.

### 5.2.1 Mobileye Alert Data

The data received through FTP feed from Apr. 4, 2019, to Feb, 29, 2020, included nearly 5 million rows in text format. Because the text data were too large to be imported into Excel, they were read and cleaned in R. It was found that the text data number of fields in some rows was inconsistent, complicating the data structure and integrity. This challenge was resolved by identifying, screening, and eliminating inconsistent rows. In addition, there were observations with the message ^KEEPALIVE^ (Figure 5-1). These values were replaced by the text “NOTHING” to indicate that there was no operational significance for these data points. This essentially, when imported into R, replaced these rows with empty rows. The R function “fread” was used to read the data; however, due to the large number of empty rows (“NOTHING” data), the import failed, which necessitated preprocessing to remove empty rows.

The text data were cleaned and filtered in R and combined with the rest of data, to be used for making an all-inclusive alert database. An example of cleaned Ituran alert data is shown in Table 5-3.


```
^ZXC012|0|29.639655|-82.323986|03/01/2020 06:32:17 |48433|58.177.1.24|SE||RTS 1804|1221 SE Veitch St, Gainesville, FL 32601, USA||^
^ZXC067|0|29.63859|-82.325018|03/01/2020 06:33:29 |42871|58.190.1.174|SE||RTS 1016|New RTS Maintenance Facility South, Gainesville, FL 32601, USA||^
^ZXC085|0|29.639781|-82.323983|03/01/2020 06:34:07 |35181|58.90.1.61|NW|17O, 17I|RTS 1805|1221 SE Veitch St, Gainesville, FL 32601, USA||^
^KEEPALIVE^
^ZXC119|0|29.638385|-82.325298|03/01/2020 06:35:33 |26836|58.177.1.123|SE||RTS 13020|New RTS Maintenance Facility North, Gainesville, FL 32601, USA||^
^KEEPALIVE^
^KEEPALIVE^
^KEEPALIVE^
^KEEPALIVE^
^ZXC040|0|29.639603|-82.32393|03/01/2020 06:37:47 |48699|58.177.1.125|SE||RTS 1803|1221 SE Veitch St, Gainesville, FL 32601, USA||^
^ZXC043|0|29.63971|-82.323896|03/01/2020 06:37:48 |44474|58.177.1.25|SE||RTS 1806|1221 SE Veitch St, Gainesville, FL 32601, USA||^
^KEEPALIVE^
^KEEPALIVE^
^ZXC121|0|29.638738|-82.324375|03/01/2020 06:38:50 |37219|58.177.1.6|SE||RTS 0703|1315 SE Veitch St, Gainesville, FL 32601, USA||^
^KEEPALIVE^
^KEEPALIVE^
^KEEPALIVE^
^KEEPALIVE^
^KEEPALIVE^
^KEEPALIVE^
^ZXC067|0|29.63859|-82.325018|03/01/2020 06:43:29 |42871|58.190.1.174|SE||RTS 1016|New RTS Maintenance Facility South, Gainesville, FL 32601, USA||^
^KEEPALIVE^
^ZXC012|0|29.639655|-82.323986|03/01/2020 06:42:17 |48433|58.177.1.24|SE||RTS 1804|1221 SE Veitch St, Gainesville, FL 32601, USA||^
^ZXC085|0|29.639781|-82.323983|03/01/2020 06:44:07 |35181|58.90.1.61|NW|17O, 17I|RTS 1805|1221 SE Veitch St, Gainesville, FL 32601, USA||^
^ZXC119|0|29.638385|-82.325298|03/01/2020 06:45:33 |26836|58.177.1.123|SE||RTS 13020|New RTS Maintenance Facility North, Gainesville, FL 32601, USA||^
^KEEPALIVE^
^KEEPALIVE^
^KEEPALIVE^
^ZXC040|0|29.639603|-82.32393|03/01/2020 06:47:47 |48699|58.177.1.125|SE||RTS 1803|1221 SE Veitch St, Gainesville, FL 32601, USA||^
^ZXC043||0|0|03/01/2020 06:47:54 |44474|58.177.1.25|||RTS 1806|!! Address not found !!||^
^ZXC043|0|29.63971|-82.323896|03/01/2020 06:47:48 |44474|58.177.1.25|SE||RTS 1806|1221 SE Veitch St, Gainesville, FL 32601, USA||^
^KEEPALIVE^
^ZXC121|0|29.638738|-82.324375|03/01/2020 06:48:50 |37219|58.177.1.6|SE||RTS 0703|1315 SE Veitch St, Gainesville, FL 32601, USA||^
^KEEPALIVE^
```


**Figure 5-1 – Telematics data in text format**

**Table 5-3. Example of Ituran alert data**

| Local Time | Vehicle Name | Heading | Address | Speed | Status Name | Latitude | Longitude |
|---|---|---|---|---|---|---|---|
| 1/8/2019 8:02 | RTS 0701 | - | Arc . | - | PDZ-R | 29.629673 | -82.366941 |
| 1/8/2019 8:19 | RTS 0701 | E | .... | 29 | PDZ-R | 29.644911 | -82.338808 |
| 1/8/2019 8:59 | RTS 0701 | NW | .... | 10 | AggBrk | 29.625636 | -82.379313 |
| 1/8/2019 9:24 | RTS 0701 | E | .... | 6 | PDZ-R | 29.644833 | -82.346853 |
| 1/8/2019 9:06 | RTS 1016 | - | .... | - | PDZ-R | 29.644841 | -82.343313 |
| 1/8/2019 9:06 | RTS 1016 | - | .... | - | PDZ-R | 29.644841 | -82.343311 |
| 1/8/2019 9:07 | RTS 1016 | - | .... | - | PDZ-R | 29.644841 | -82.34336 |
| 1/8/2019 9:07 | RTS 1016 | - | .... | - | PDZ-R | 29.644841 | -82.34338 |
| 1/8/2019 9:40 | RTS 1302 | - | .... | - | PDZ-R | 29.637645 | -82.365216 |
| 1/8/2019 9:58 | RTS 1302 | - | .... | - | PDZ-R | 29.644828 | -82.343645 |
| 1/8/2019 9:58 | RTS 1302 | - | .... | - | PDZ-R | 29.644828 | -82.343631 |
| 1/8/2019 10:56 | RTS 0701 | S | .... | 32 | PDZ-R | 29.647231 | -82.32238 |

### 5.2.2 Route Data

Gainesville RTS vehicles changed routes frequently during the study period, and Ituran data were bus-specific and not route-specific; therefore, a manual process was adopted. ArcGIS was used to overlay each day's alerts with RTS routes, which was used to filter data for each route and for each day. The alerts of each RTS vehicle were plotted by day using R script; a total of 2,954 plots (422 days × 7 buses) was generated. The plots were compared with RTS routes to find the route of each vehicle. As shown in Figure 5-2, most of the weekends (highlighted in the figure) have no data or minimal data and thus did not allow route correlation. As such, only weekday data were considered in the route data analysis.

With the above methodology, the routes were correlated to the vehicles. Table 5-4 shows the aggregate results of the correlations. Of the 2,100 vehicle-days (422 days × 5 buses), 707 days had no alert to be used for route identification. Overall, the routes for 1,341 vehicle-days were defined, and 52 were not correlated.

**Table 5-4. Summary of route correlation**

| | Open | Stealth | All |
|---|---|---|---|
| Defined | 1,150 | 191 | 1,341 |
| Undefined | 47 | 5 | 52 |
| No Conflicts | 609 | 98 | 707 |
| Total | 1,806 | 294 | 2,100 |

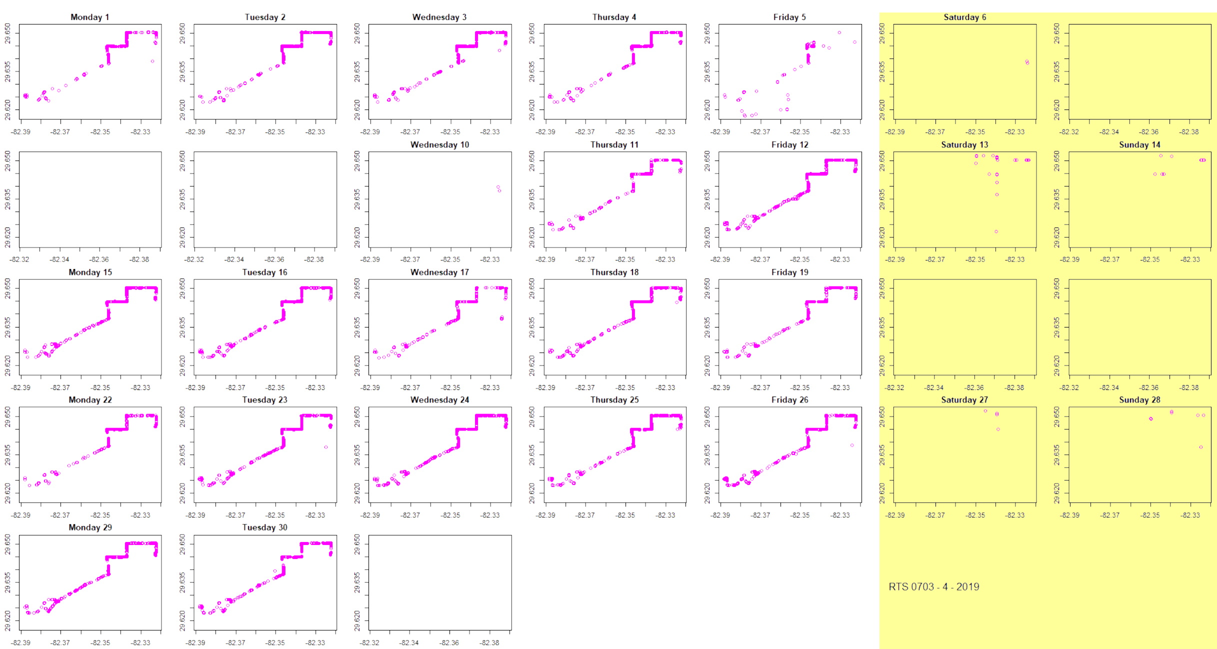



**Figure 5-2 – Example of day-by-day plots of alerts**

As shown in Table 5-5, using the developed data plots, 32 routes were defined that were used by seven buses. Of the 32, only five routes had more than four days of data in both open and stealth mode (Table 5-6). This criterion was chosen: routes must have at least five days of data in both the before and after periods. The routes in Table 5-6 were used for further route-based analysis. The data for these five routes includes a total of 1,294 vehicle-days: 185 vehicle-days in stealth mode and 1,109 in open mode.

**Table 5-5. List of defined routes with the number of days observed**

| Route | Number of Vehicle-Days | | |
|---|---|---|---|
| | Open | Stealth | All |
| 1 | 135 | 35 | 170 |
| 3 | 2 | | 2 |
| 5 | 89 | 5 | 94 |
| 6 | 2 | 1 | 3 |
| 7 | 2 | 1 | 3 |
| 8 | 168 | 60 | 228 |
| 9 | 5 | 1 | 6 |
| 10 | 4 | | 4 |
| 11 | 1 | | 1 |
| 12 | 95 | | 95 |
| 13 | 4 | 3 | 7 |
| 15 | 8 | 1 | 9 |
| 16 | 23 | 26 | 49 |
| 17 | 28 | | 28 |
| 20 | 24 | 3 | 27 |
| 21 | 161 | | 161 |
| 23 | 1 | | 1 |
| 25 | 1 | | 1 |
| 34 | 86 | | 86 |
| 35 | 4 | | 4 |
| 37 | | 22 | 22 |
| 39 | 2 | | 2 |
| 40 | 91 | | 91 |
| 43 | 8 | 1 | 9 |
| 46 | | 1 | 1 |
| 75 | 46 | | 46 |
| 76 | 22 | | 22 |
| 117 | 97 | 25 | 122 |
| 118 | 1 | 3 | 4 |
| 120 | 1 | | 1 |
| 122 | | 3 | 3 |
| 125 | 39 | | 39 |

**Table 5-6. List of routes with more than 4 days observed in both stealth and open mode**

| Route | Number of Vehicle-Days | | |
|---|---|---|---|
| | Open | Stealth | All |
| 1 | 135 | 35 | 170 |
| 5 | 89 | 5 | 94 |
| 8 | 168 | 60 | 228 |
| 16 | 23 | 26 | 49 |
| 117 | 97 | 25 | 122 |

## 5.3 Performance Evaluation

Two different analysis approaches were undertaken in this study:

1. Aggregate analysis of all vehicle conflicts
2. Route-by-route analysis.

Figure 5-3 shows an overview of the data scrubbing process and the associated challenges at every stage. The challenges with data volume, false alerts, and data structure were outlined with examples in the earlier section. The following sections focus on the challenges and solutions of the aggregate analysis and route-based analysis.

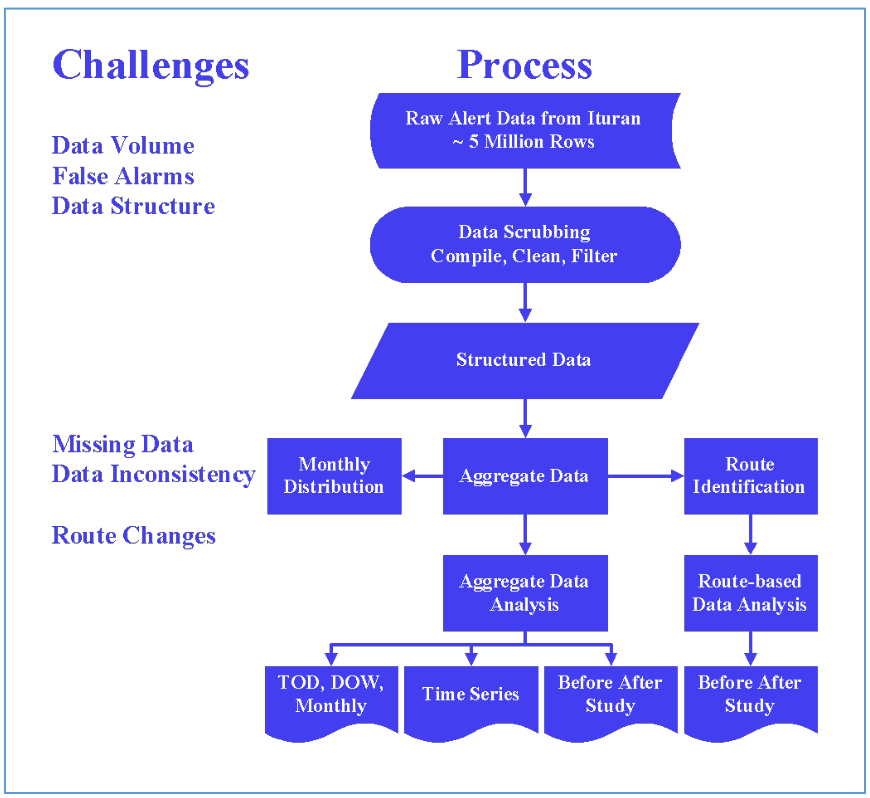



**Figure 5-3 – Data scrubbing procedure and challenges**

## 5.4 Aggregate Analysis

For this analysis, all the vehicles' combined alerts were analyzed to understand the hourly, daily, and monthly distribution of alerts and to compare the stealth mode and open mode before and after the installation of the driver assistance system.

Table 5-7 summarizes the total number of observations of various alerts from the seven buses between Jan. 4, 2019, and Feb. 29, 2020. The alerts from various cameras were aggregated for each of the following six alerts. There were 653,343 PDZ alerts (pedestrian detections). The pedestrian collision warning (PCW) alerts were 4.67% of the PDZs. The most observed vehicular alert was the urban forward collision warning (UFCW): 159,623. The UFCWs are low-speed forward collision warnings (<19 mph). There was a much lower number of high speed forward collision warnings (FCW): 2,370, of which 2,127 were aggressive braking (AggBrk) alerts that could result from either vehicles or pedestrians. These are just aggregate numbers that cannot give a deep insight into the effectiveness of the system. In the next subsections, the alerts will be analyzed in more detail, normalized to vehicle miles travelled and compared between stealth and open modes.

**Table 5-7. Number of various alerts**

| | Pedestrian | | Vehicular | | | |
|---|---|---|---|---|---|---|
| | **PDZ** | **PCW** | **UFCW** | **FCW** | **HW Warning** | **Aggressive Braking** |
| Alerts | 653,343 | 30,531 | 159,623 | 2,370 | 14,296 | 2,127 |

### 5.4.1 Time of Day, Weekday, and Monthly Distribution

The first step to evaluate the alerts distribution was to find the daily, weekly, and monthly distributions of the alerts. The alerts are sorted into three main categories: pedestrian related, vehicular alerts, and aggressive braking.

Figure 5-4 shows the hourly distribution of (a) pedestrian-related, (b) vehicular, and (c) aggressive braking alerts. Vehicular and aggressive braking follow the same pattern. Pedestrian-related alerts between 9 p.m. to 6 a.m. are lower in comparison to the other two categories (vehicular and aggressive braking). During 9 p.m. to 6 a.m., the traffic flow and pedestrian demand are considerably lower than in the daytime. The UFCW peak is between 4 p.m. to 6 p.m. This is due to the afternoon peak when the

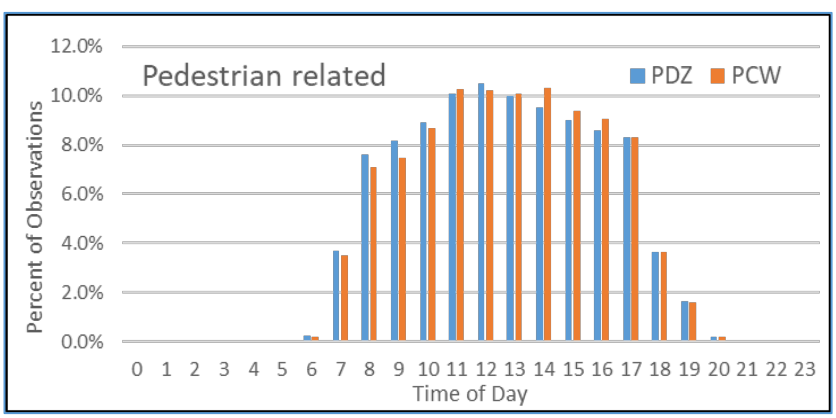



**Figure 5-4 – Hourly distribution of alerts: (a) Pedestrian**

traffic flow exhibits low speeds. As previously mentioned, the UFCWs are alerts with speed lower than 19 mph.

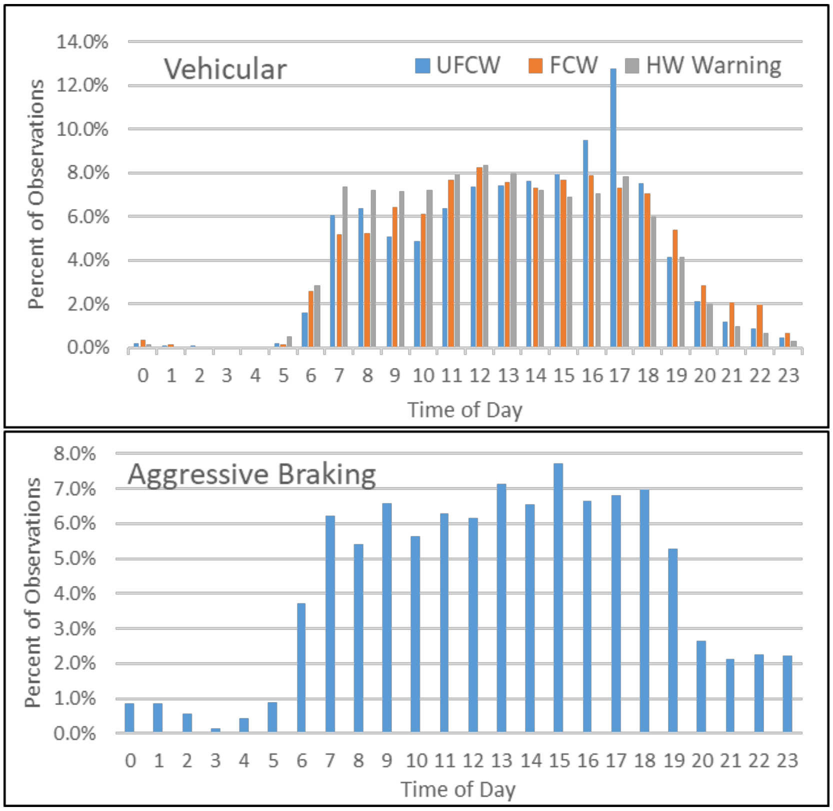



**Figure 5-4 – Hourly distribution of alerts: (b) Vehicle; (c) Aggressive braking**

Hourly peaks were expected in each of three periods: morning, noon, and afternoon. However, the plots in Figure 5-4 are all bell-shaped. This could be due to the nature of demand in Gainesville as a college town. Various conflict speed filters were used to see if there was any different trend for conflicts.

Figure 5-5 shows the distribution of PDZs and HWWs (headway warnings) with speed more than 20 mph (the remaining conflicts were less than 200 observations). As shown in Figure 5, both HWW and PDZ have a pattern with three peaks.

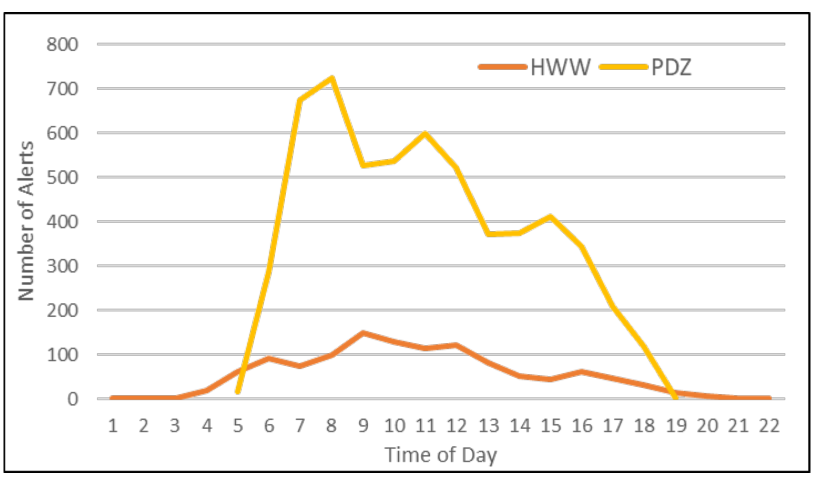



**Figure 5-5 – PDZ and HWW with speed more than 20 mph**

Figure 5-6 shows the weekday distribution of the alerts. The number of alerts on the weekends are lower than the weekdays due to lower demand on weekends generally. The nature of Gainesville as a college town amplifies the demand difference between weekdays and weekends because the University is closed on weekends. The proportion of alerts on weekdays fluctuates between 17% and 22%.

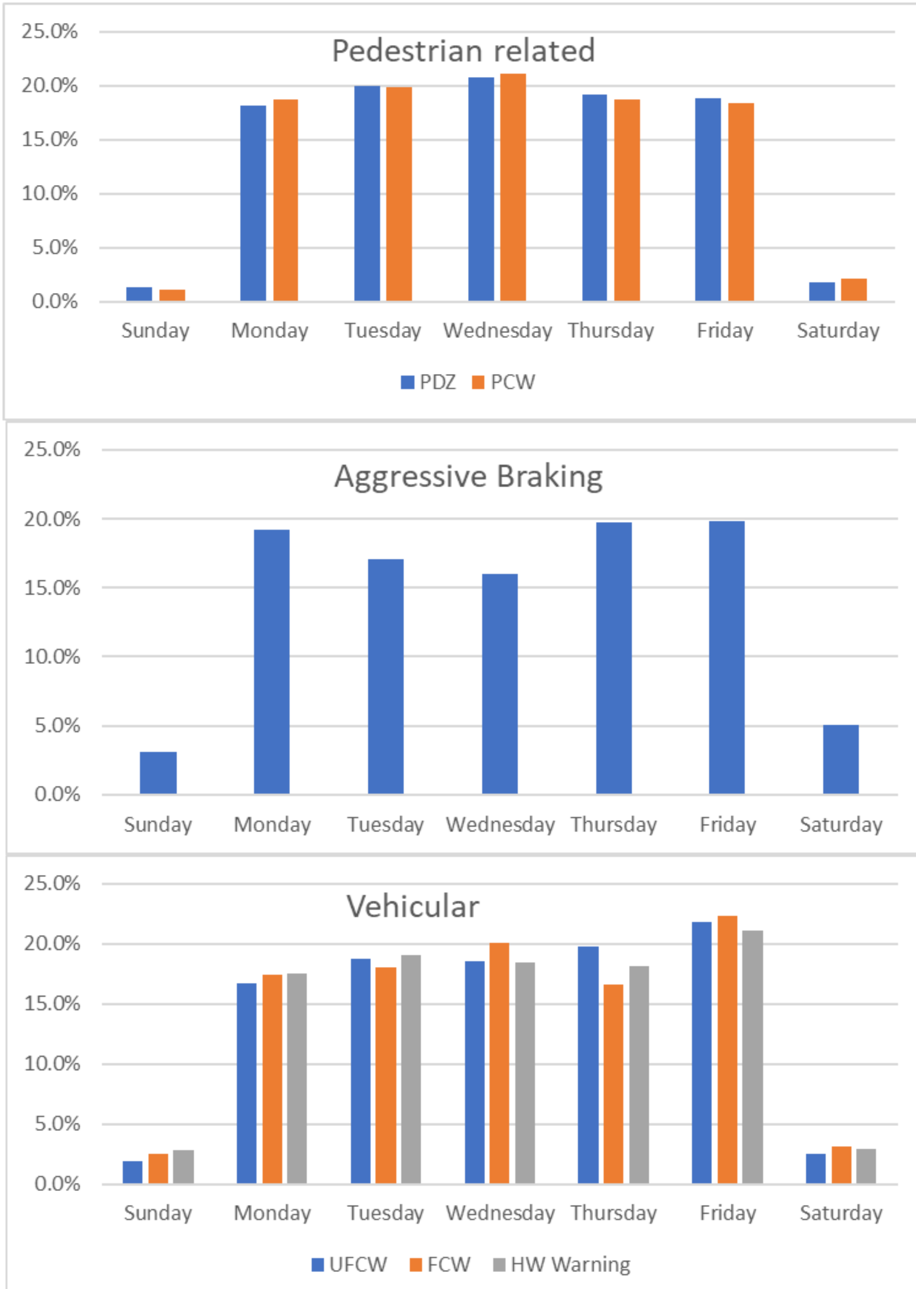



**Figure 5-6 – Daily distribution of pedestrian, vehicular, and aggressive braking alerts**

Figure 5-7 shows the monthly distribution of miles travelled by the buses.

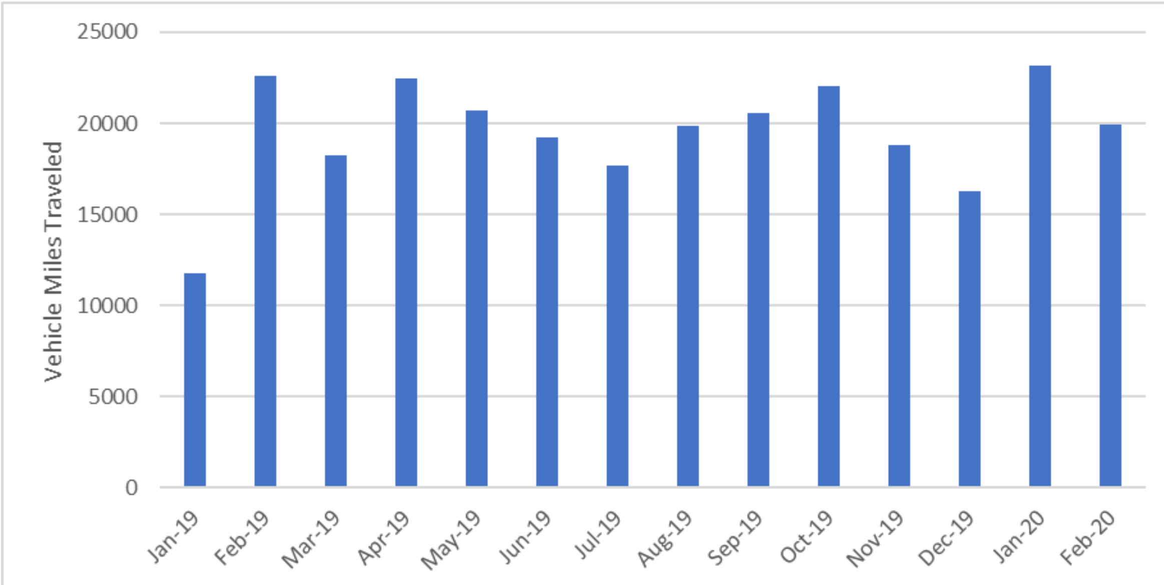



**Figure 5-7 – Monthly distribution of miles travelled by the buses**

On the following pages, Table 5-8 shows the monthly distribution of all alerts and total miles travelled by the seven buses. Table 5-9 shows the same data, normalized to row totals. In Figure 5-8, the alert data of Table 5-9 are presented in three graphs. The three semesters of the University of Florida academic year are indicated in the graphs, and the dotted gray line shows the border between stealth and open mode.

In the pedestrian alerts graph of Figure 5-8, PDZ alerts are consistent throughout the observation period. The PCW alerts are strongest during the fall semester and show a significant decrease during the summer semester. In the vehicular alerts graph of Figure 5-8, alerts show a similar trend in the spring semester: low in January and rising in February; however, FCW and HWW alerts rise in the summer and decrease to low levels in the fall while UFCW alerts show opposite trends. As hypothesized, FCW alerts, activated at speeds under 19 mph, act against UFCW alerts, activated at speeds above 19 mph. In the aggressive braking graph of Figure 5-8, there is a decreasing trend in aggressive braking during the open alert period. We hypothesize that this is due to improved driving behavior.

Table 5-8. Monthly observed alerts

| Mode | Month | Alert | | | | | | Miles |
|---|---|---|---|---|---|---|---|---|
| | | PDZ | PCW | UFCW | FCW | HWW | AggBrk | |
| Stealth | Jan | 43,466 | 2,665 | 10,999 | 117 | 822 | 182 | 11,780 |
| | Feb | 43,497 | 3,133 | 14,990 | 218 | 1,524 | 177 | 22,597 |
| Open | Mar | 43,525 | 1,657 | 10,486 | 152 | 1,080 | 213 | 18,235 |
| | Apr | 43,556 | 2,501 | 9,612 | 197 | 1,043 | 192 | 22,429 |
| | May | 43,586 | 1,155 | 9,553 | 250 | 1,314 | 224 | 20,722 |
| | Jun | 43,617 | 1,027 | 9,716 | 284 | 1,382 | 165 | 19,249 |
| | Jul | 43,647 | 954 | 7,109 | 215 | 882 | 206 | 17,698 |
| | Aug | 43,678 | 2,286 | 13,752 | 173 | 1,063 | 105 | 19,853 |
| | Sep | 43,709 | 3,503 | 15,513 | 137 | 1,031 | 68 | 20,549 |
| | Oct | 43,739 | 3,138 | 13,501 | 110 | 868 | 90 | 22,029 |
| | Nov | 43,770 | 2,587 | 12,759 | 124 | 952 | 111 | 18,809 |
| | Dec | 43,800 | 1,080 | 7,784 | 96 | 814 | 158 | 16,283 |
| | Jan | 43,831 | 2,434 | 11,062 | 119 | 696 | 96 | 23,197 |
| | Feb | 43,862 | 2,411 | 12,787 | 178 | 825 | 140 | 19,916 |
| | Total | 611,283 | 30,531 | 159,623 | 2,370 | 14,296 | 2,127 | 273,345 |

Table 5-9. Monthly observed alerts, normalized to alert totals (percent)

| Mode | Month | Alert | | | | | | Miles |
|---|---|---|---|---|---|---|---|---|
| | | PDZ | PCW | UFCW | FCW | HWW | AggBrk | |
| Stealth | Jan | 7.1 | 8.7 | 6.9 | 4.9 | 5.7 | 8.6 | 4.3 |
| | Feb | 7.1 | 10.3 | 9.4 | 9.2 | 10.7 | 8.3 | 8.3 |
| Open | Mar | 7.1 | 5.4 | 6.6 | 6.4 | 7.6 | 10.0 | 6.7 |
| | Apr | 7.1 | 8.2 | 6.0 | 8.3 | 7.3 | 9.0 | 8.2 |
| | May | 7.1 | 3.8 | 6.0 | 10.5 | 9.2 | 10.5 | 7.6 |
| | Jun | 7.1 | 3.4 | 6.1 | 12.0 | 9.7 | 7.8 | 7.0 |
| | Jul | 7.1 | 3.1 | 4.5 | 9.1 | 6.2 | 9.7 | 6.5 |
| | Aug | 7.1 | 7.5 | 8.6 | 7.3 | 7.4 | 4.9 | 7.3 |
| | Sep | 7.2 | 11.5 | 9.7 | 5.8 | 7.2 | 3.2 | 7.5 |
| | Oct | 7.2 | 10.3 | 8.5 | 4.6 | 6.1 | 4.2 | 8.1 |
| | Nov | 7.2 | 8.5 | 8.0 | 5.2 | 6.7 | 5.2 | 6.9 |
| | Dec | 7.2 | 3.5 | 4.9 | 4.1 | 5.7 | 7.4 | 6.0 |
| | Jan | 7.2 | 8.0 | 6.9 | 5.0 | 4.9 | 4.5 | 8.5 |
| | Feb | 7.2 | 7.9 | 8.0 | 7.5 | 5.8 | 6.6 | 7.3 |
| | Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

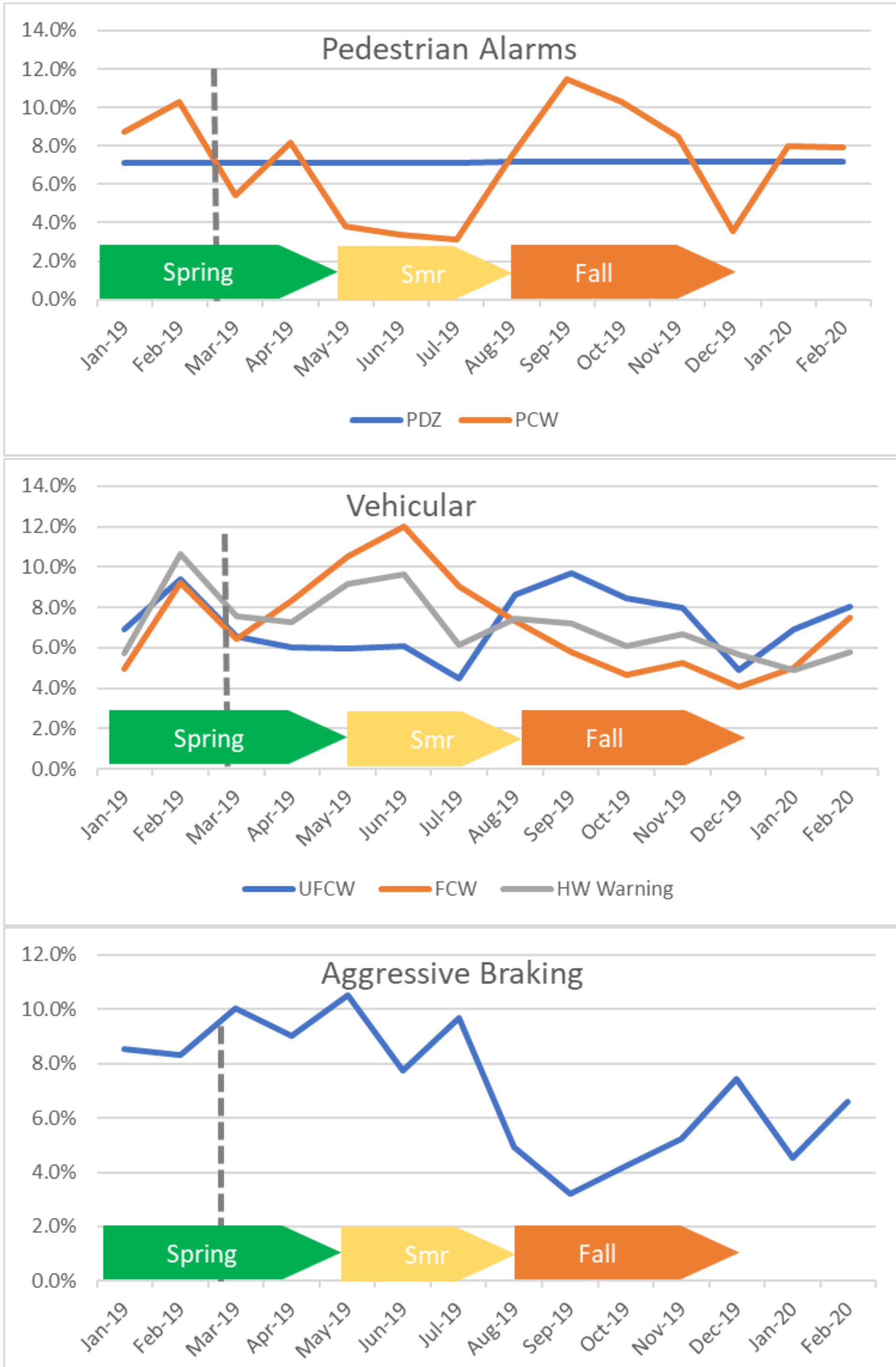



**Figure 5-8 – Monthly distribution of pedestrian, vehicular, and aggressive braking alerts**

### 5.4.2 Time Series of the Alerts

This section focuses on the changes in the normalized trends of various alerts after Mobileye Shield+ alerts were displayed to drivers (open mode). The time-of-day, weekday, and monthly distribution of miles travelled can be used as an exposure measure to normalize the observations. The results in this section are normalized to miles travelled. Figure 5-9 to Figure 5-11 respectively show the VMT-normalized pedestrian, vehicular, and aggressive braking alerts. The y-axis in each figure shows the alerts per 1,000 miles travelled. The dotted line in these figures shows the border between stealth and open modes. The University of Florida semesters are also marked in these figures.

As shown in Figure 5-9, there is fluctuation in the PDZ alerts between spring, summer, and fall semester period. Generally, the alerts have been lower in the open period (summer and Fall) when compared to the stealth period. The trend line also shows a downward trend longitudinally over the period of deployment.

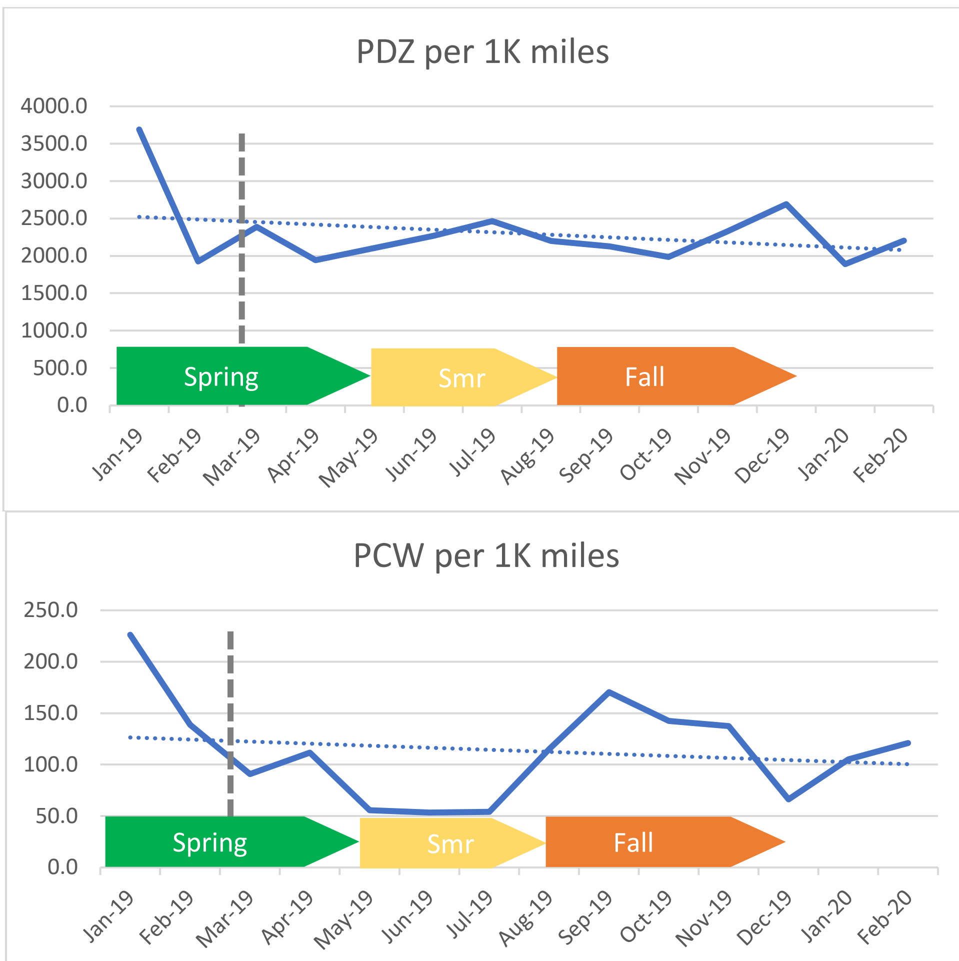
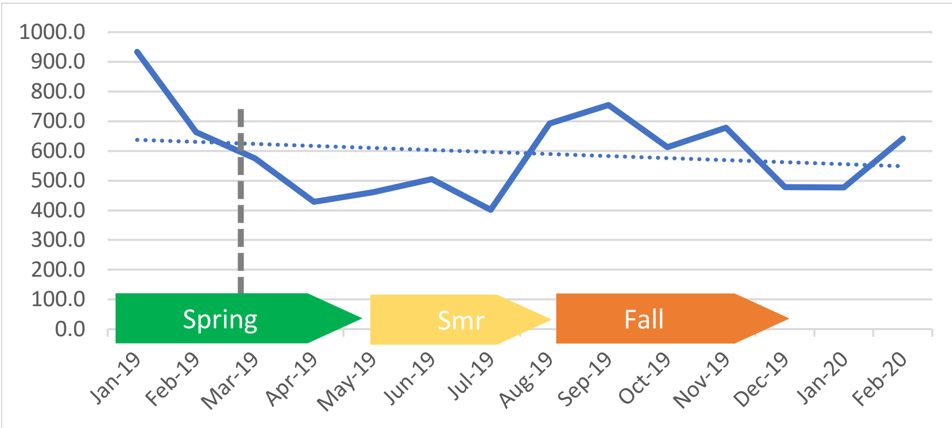


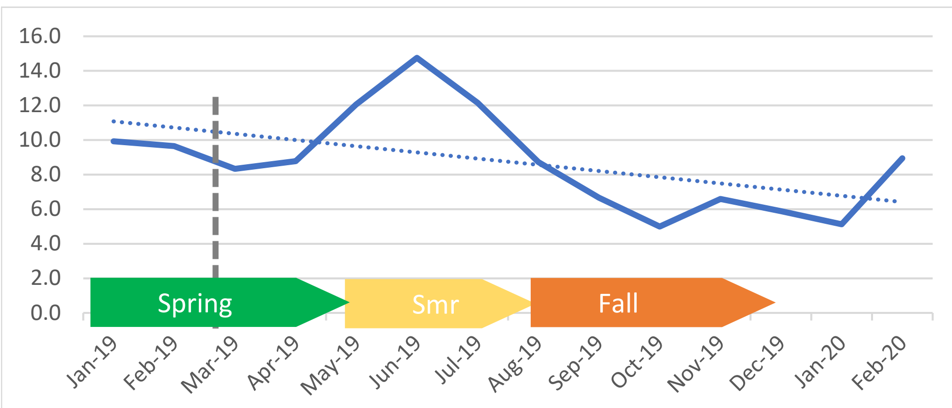

**Figure 5-9 – Monthly distribution of normalized pedestrian alerts**

The vehicular alerts in Figure 5-10 showed a decreasing trend, as well as pedestrian alerts in Figure 5-9. The comparison of decreasing trend slope is possible; however, in the next section, the stealth and open mode will be compared.

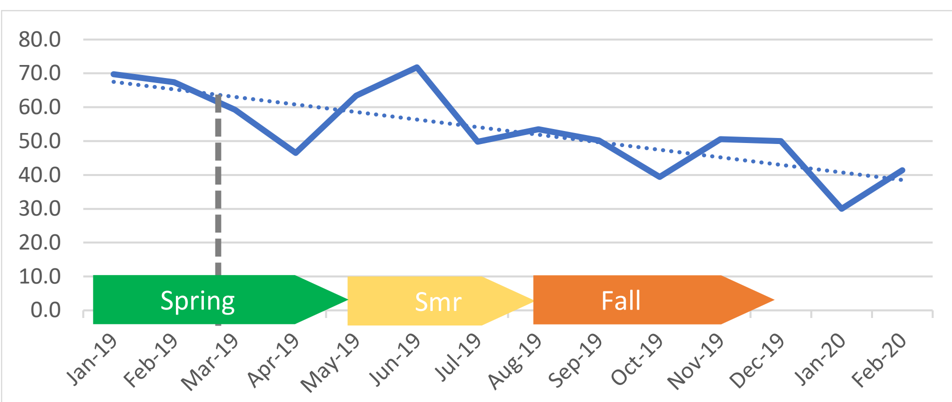
Trends in the UFCW and FCW distributions are complementary because the UFCW alerts are for speeds lower than 19 mph and FCW alerts are for speeds higher than 19 mph. The maximum of FCW is in June (summer semester).




UCW per ,000 miles




FCW per 1,000 miles




HWW per 1,000 miles

**Figure 5-10 – Monthly distribution of normalized vehicular alerts**

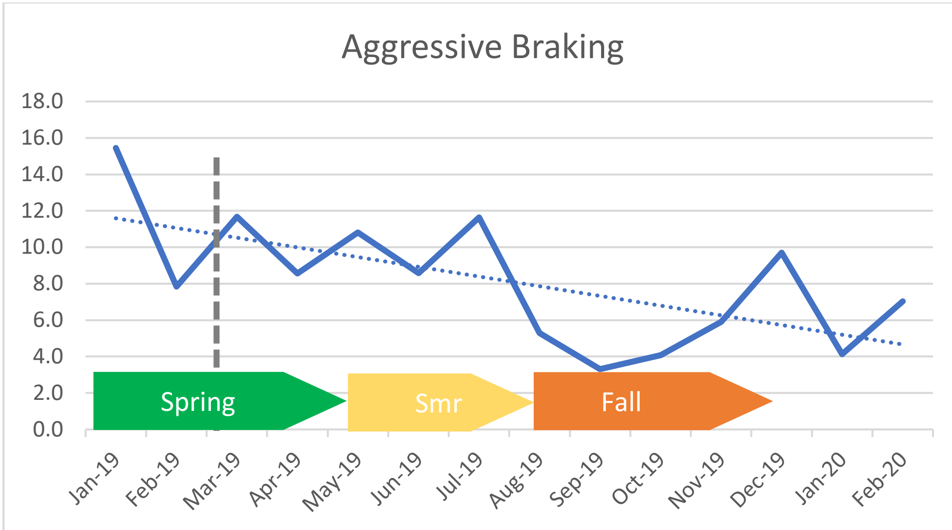



**Figure 5-11 – Monthly distribution of normalized aggressive braking alerts**

In Figure 5-11 there is a considerable decreasing trend in aggressive braking. Interestingly, the lowest normalized aggressive braking is in September when student demand is highest and when buses are in their fullest condition.

### 5.4.3 Before-After Analysis

This section focuses on the comparison between stealth and open modes to quantify the effectiveness of the driver assistance system in enhancing the safety and possibly changing the driver's behavior over time. The ADAS system was operating in stealth mode between Jan. 4 and Mar. 4, 2019. Afterwards, it operated in open mode beginning Mar. 5, 2019, and continuing until Feb 29, 2020. In the before-after analysis, stealth mode is considered "Before", and the rest of the period is "After".

The open mode period included summer semester that has a lower exposure due to the lower number of students attending the university. Generally, neglecting the exposure could bias the results; however, there was no mechanism to quantify pedestrian exposure for the extended period and for the route length. As an alternative, two different approaches were adopted. First, a comparison was made for the same period for two calendar years. In addition, a surrogate exposure measure was considered that is explained in a subsequent section.

Table 5-10 summarizes the before-after analysis of the alerts. The observations in this table are normalized by total miles travelled. The percent change in this table was calculated through the following formula:

$$Percent\ Change\ in\ Alerts = \frac{\text{Stealth} - \text{Open}}{Stealth} \times 100 \qquad (5\text{-}1)$$

**Table 5-10. VMT-normalized observations of stealth and open modes**

| Alert | Number of Alerts | | | Percent Decrease | |
|---|---|---|---|---|---|
| | Stealth | All Stealth Mode | Open 2020 only | All Stealth Mode | 2020-only |
| PDZ | 2,530 | 2,194 | 2,034 | 13.3% | 19.6% |
| PCW | 168.7 | 103.5 | 112 | 38.6% | 33.4% |
| UFCW | 756.0 | 559.2 | 553 | 26.0% | 26.8% |
| FCW | 10 | 9 | 7 | 12.6% | 29.3% |
| HWW | 68 | 50 | 35 | 26.7% | 48.3% |
| AggBrk | 10 | 7 | 5 | 29.2% | 47.6% |

Both PDZ and PCW alerts decreased in the open mode: PDZ decreased by 13.3% and 19.6% and by 13.3% when conflicts in stealth mode were compared with all year of active data. PDZ decreased by 19.6% when stealth was compared to similar dates in two calendar years. Pedestrian collision warning, which is more critical in quantifying safety, decreased by 38.6% and 33.4%.

Urban forward collision warning (UFCW: speed<19 mph) decreased by 26.0% and 26.8%. The decrease in forward collision warning was 12.6% and 29.3%. The last rear-end-related warning, headway warning, decreased by 26.7% and 48.3%.

Aggressive breaking decreased by 29.2% and 47.6% in the open periods. All the warnings decreased during the open mode period, which shows the drivers' behavior improved and reduced pedestrian and vehicular conflicts. The average of reductions in the last column of Table 5-10 is 34.17%. This translates to an average Conflict Modification Factor (CoMF) of 65.83%.

In Table 5-10, the decrease in alerts is greater when stealth mode conflicts were compared to similar dates in active mode in 2020.

### 5.4.4 Route-based Analysis

As shown in Figure 5-12, each conflict from the Mobileye Ituran includes all the routes passing through that point; however, it does not provide unique route-based data. As an alternative, the methodology mentioned in the Data Collection and Processing section was developed to identify the routes of vehicles. Five routes during weekdays were selected for analysis. An example of the collected route data is shown in Table 5-11. Each row includes the route, travelled miles, and stealth indicator for each vehicle on each day.

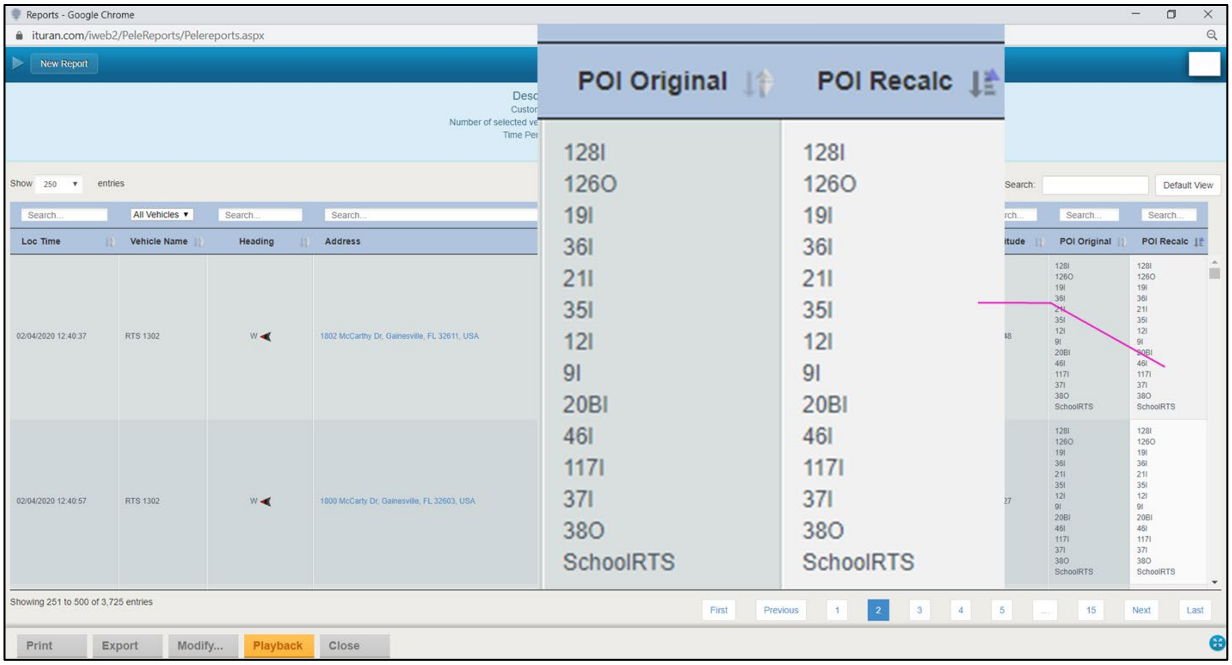



**Figure 5-12 – Routes shown for one conflict**

**Table 5-11. Collected route data example**

| ID | Vehicle | YYYYMMDD | Date | Route | Miles Travelled | Stealth | Day of Week | Day of Study |
|---|---|---|---|---|---|---|---|---|
| 70120190108 | 701 | 20190108 | 1/8/2019 | 1 | 118.68 | Y | Wed. | 8 |
| 101620190108 | 1016 | 20190108 | 1/8/2019 | 16 | 144.8 | Y | Wed. | 8 |
| 130220190108 | 1302 | 20190108 | 1/8/2019 | 117 | 126.2 | Y | Wed. | 8 |
| 101620190109 | 1016 | 20190109 | 1/9/2019 | 16 | 114.8 | Y | Thurs. | 9 |
| 130220190109 | 1302 | 20190109 | 1/9/2019 | 117 | 126.2 | Y | Thurs. | 9 |
| 180320190109 | 1803 | 20190109 | 1/9/2019 | 8 | 213.9 | Y | Thurs. | 9 |
| 180620190109 | 1806 | 20190109 | 1/9/2019 | 8 | 158.9 | Y | Thurs. | 9 |
| 101620190110 | 1016 | 20190110 | 1/10/2019 | 16 | 140.4 | Y | Fri. | 10 |

The Ituran alerts from Mobileye were correlated with the selected five routes. For this option, day-by-day data from the Ituran Safety tab (Figure 5-13) were used. This approach was undertaken because the data were already aggregated for each vehicle by day. However, the initial analysis showed that the numbers from this tab (period summary daily) were about 5 percent in excess of the data used in aggregate analysis. Using the period summary daily data from Ituran could have biased the results. It should be noted that in the route-based analysis section, the latitude and longitude of each individual alert was required to define each vehicle's daily route (see also Table 5-3) and, as such, the day-by-day data from the Ituran Safety tab could not be used for both aggregate and route-based analyses.

Finally, the disaggregated alert data were correlated with routes by using key values of date and vehicle number.

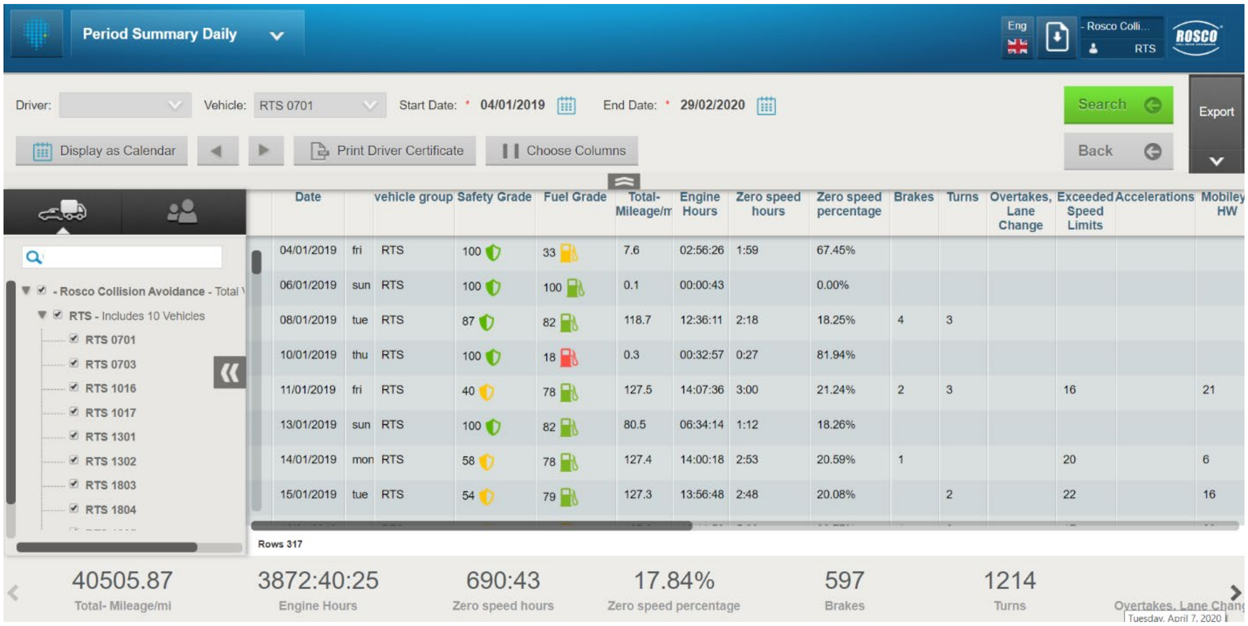



**Figure 5-13 – Example of day-to-day results from Ituran Safety tab**

In the Status Name column in Table 5-12 alerts are coded for different cameras. These alerts were aggregated in the Aggregated Alert column for all cameras.

After initial data analysis, it was discovered that the Ituran shows zero (or very low) miles travelled for vehicles for some days, while there were alerts reported in the system for that specific vehicle on that day. Further analysis revealed that the data were aggregated with the vehicle mileage on the next day. This was evident since the data showed almost double the average miles travelled of that specific vehicle (Table 5-13). This issue does not affect the aggregate analysis because data are aggregated for the whole analysis period. However, in the route-based analysis, because the vehicles are serving on different routes, this could bias the results – especially because one vehicle can serve on two different routes on two consecutive days. To avoid such bias, these observations were filtered, reviewed individually, and corrected. Table 5-14 shows the miles travelled on each of the five routes in stealth and open mode.

**Table 5-12. A selection of columns of final database for route-based analysis**

| ID | Speed | Status Name | Day of Week | Aggregated Alert | Route | Mode | Miles |
|---|---|---|---|---|---|---|---|
| 70320190117 | 14 | ME (Pedestrian In Range Warning} | Thurs | PDZ | 1 | S | 164.5 |
| 180620190218 | 7 | PDZ-R | Mon | PDZ | 8 | S | 159.9 |
| 101620190110 | 7 | PDZ-LR | Thurs | PDZ | 16 | S | 140.4 |
| 130220190129 | 12 | PDZ-R | Tues | PDZ | 117 | S | 126.1 |
| 180320190815 | 37 | ME (Headway Warning) | Thurs | HW | 8 | O | 175 |
| 180520190328 | 21 | M (Pedestrian In Range Warning) | Thurs | PDZ | 5 | O | 226.3 |
| 130220200121 | 1 | PDZ-LR | Tues | PDZ | 117 | O | 115.4 |
| 70320190226 | 7 | PDZ (Left Front) | Tues | PDZ | 1 | S | 83.2 |
| 180520191030 | 29 | ME (Headway Warning) | Wed | HW | 1 | O | 106.1 |
| 180320190624 | 21 | ME (Pedestrian In Range Warning) | Mon | PDZ | 8 | O | 174.1 |
| 180320190130 | 9 | ME (Pedestrian In Range Warning) | Wed | PDZ | 8 | S | 0.3 |
| 101620190116 | 9 | PDZ-R | Wed | PDZ | 16 | S | 110.8 |
| 130220190114 | 12 | PDZ-R | Mon | PDZ | 117 | S | 126 |
| 130220190422 | 7 | PDZ-R | Mon | PDZ | 117 | O | 126.1 |
| 180620190227 | 21 | PDZ-LR | Wed | PDZ | 8 | S | 160.5 |
| 130220191001 | 15 | PDZ-R | Tues | PDZ | 117 | O | 121 |
| 180620190214 | 17 | PDZ-R | Thurs | PDZ | 8 | S | 161.2 |
| 180620190218 | - | PDZ-R | Mon | PDZ | 8 | S | 159.9 |
| 180620190715 | 0 | PDZ-LR | Mon | PDZ | 5 | O | 143.8 |
| 180320190611 | 11 | PDZ-LR | Tues | PDZ | 8 | O | 174.7 |
| 180320190228 | 6 | PDZ-R | Thurs | PDZ | 8 | S | 214.8 |

**Table 5-13. Example of Ituran mileage malfunction**

| ID | Vehicle | YYYYMMDD | Date | Route | Miles Travelled | Stealth | Day of Week | Day of Study |
|---|---|---|---|---|---|---|---|---|
| 70120190225 | 701 | 20190225 | 2/25/2019 | 1 | 127.44 | Y | Tues | 25 |
| 70120190226 | 701 | 20190226 | 2/26/2019 | 1 | 0 | Y | Wed | 26 |
| 70120190227 | 701 | 20190227 | 2/27/2019 | 1 | 326.9 | Y | Thurs | 27 |

**Table 5-14. Miles travelled on each route in stealth and open mode**

| | Number of Vehicle-Days | | | Miles Travelled | | |
|---|---|---|---|---|---|---|
| Route | Stealth | Open | Total | Stealth | Open | Total |
| 1 | 35 | 135 | 170 | 5,000 | 16,985 | 21,725 |
| 5 | 5 | 89 | 94 | 806 | 12,732 | 12,691 |
| 8 | 60 | 168 | 228 | 11,263 | 28,542 | 39,562 |
| 16 | 26 | 23 | 49 | 3,838 | 3,239 | 6,720 |
| 117 | 25 | 97 | 122 | 3,094 | 11,772 | 14,751 |

## 5.5 Routes Map and Characteristics

Figure 5-14 and Figure 5-15 show the five routes that are the focus of this section. Gator Locator is a Web interface that shows the location and route of each RTS bus. The next sections focus on the evaluation of pedestrian, vehicular, and aggressive braking alerts.

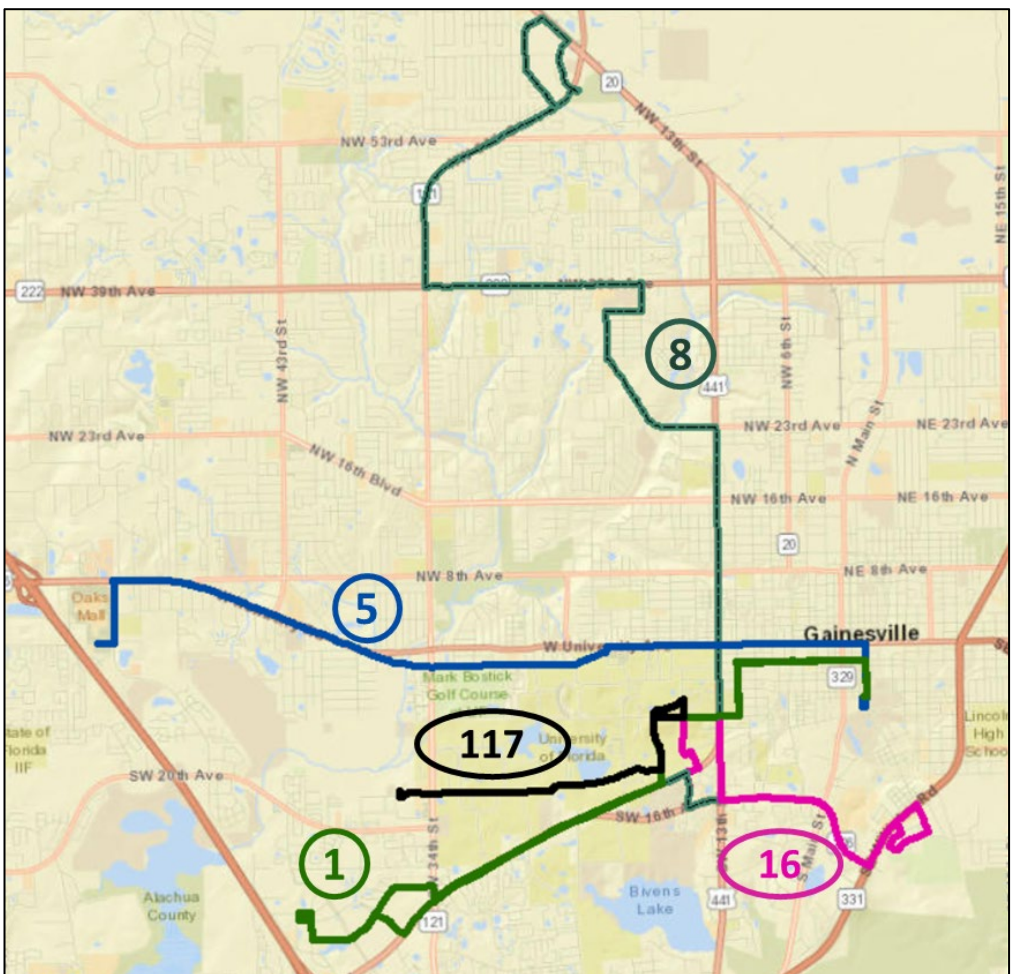



**Figure 5-14 – Map of RTS bus routes 1, 5, 8, 16, and 117**

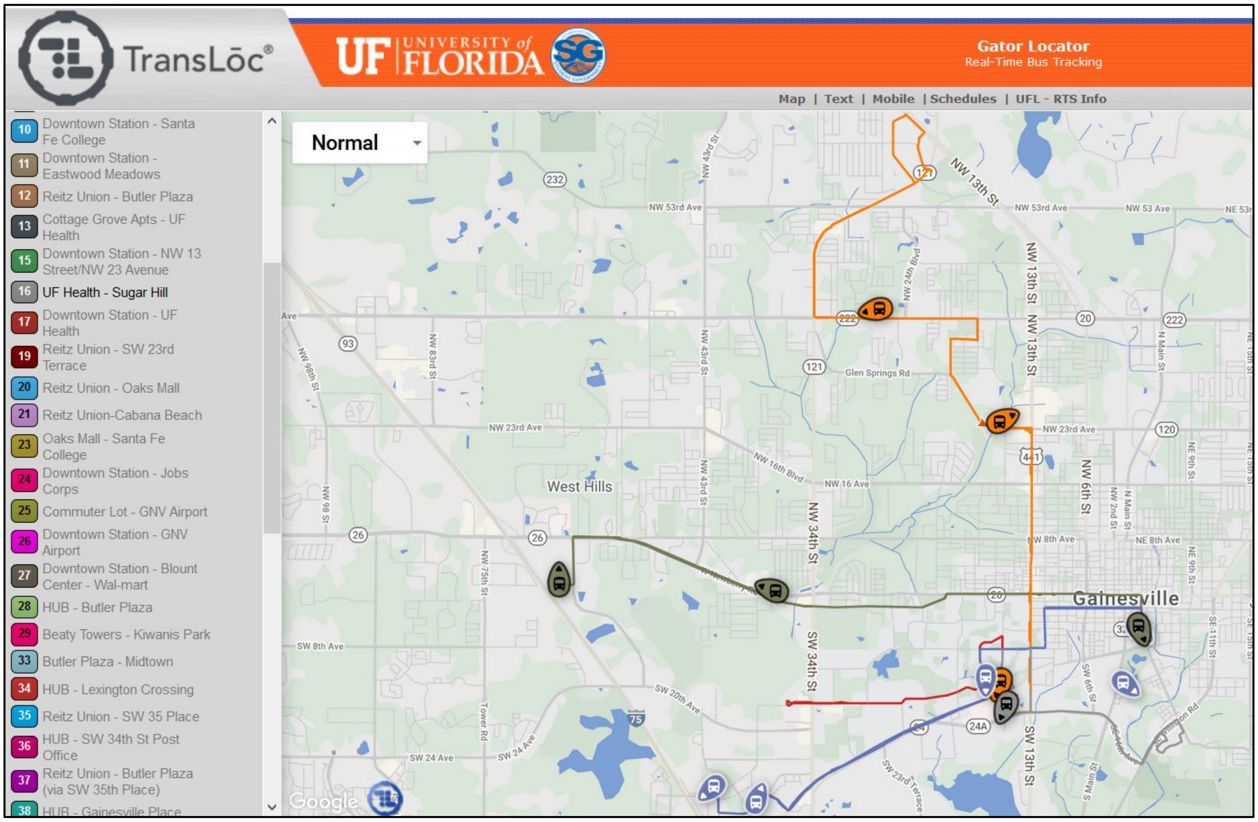



**Figure 5-15 – Gator Locator view of bus routes (https://ufl.transloc.com/)**

### 5.5.1 Pedestrian-related Alerts

The purpose of this section is to compare pedestrian alerts between stealth and open modes. Pedestrian alerts include PDZs and PCWs. As shown in Table 5-15, VMT-normalized PDZs decreased in all routes, ranging from 56.6% to 89.2%.

**Table 5-15. Route-based analysis of PDZ**

| | Observed | | 1,000 VMT-Normalized | | |
|---|---|---|---|---|---|
| Route | Stealth | Open | Stealth | Open | Percent Reduction |
| 1 | 16,713 | 14,500 | 3,342.6 | 853.7 | 74.5% |
| 5 | 939 | 6,430 | 1,164.7 | 505.0 | 56.6% |
| 8 | 18,114 | 7,267 | 1,608.2 | 254.6 | 84.2% |
| 16 | 8,294 | 1,428 | 2,161.1 | 440.8 | 79.6% |
| 117 | 25,529 | 10,500 | 8,250.3 | 892.0 | 89.2% |

Table 5-16 summarizes the route-based analysis of PCW alerts for stealth and open mode. The PCW in open mode increased by 4.0% and 3.1% for routes 5 and 8, respectively. This is while the other routes experienced reductions of 10.7%, 11.8%, and 25.5%.

**Table 5-16. Route-based analysis of PCW**

| Route | Observed | | 1,000 VMT-Normalized | | Percent Reduction |
|---|---|---|---|---|---|
| | Stealth | Open | Stealth | Open | |
| 1 | 760 | 2,278 | 15.0 | 134.1 | 11.8 |
| 5 | 36 | 561 | 44.7 | 43.4 | −4.0 |
| 8 | 533 | 1,393 | 47.3 | 48.8 | −3.1 |
| 16 | 357 | 269 | 93.0 | 83.0 | 10.7 |
| 117 | 2,020 | 5,723 | 652.8 | 486.2 | 25.5 |

### 5.5.2 Vehicular Alerts

This section compares the vehicular alerts, including FCW, UFCW, and HWW, for the five routes between stealth and open modes. The results of these alerts are in Table 5-17, Table 5-18, and Table 5-19, respectively. The number of FCWs in stealth mode for routes 5 and 16 in Table 5-17 are 3 and 4, respectively. The low number of observations for these two routes makes the conclusions statistically insignificant. The other three routes showed reductions in FCW ranging from 7.4% and 27.8%. As shown in Table 18, the UFCW on all the routes showed a reductions ranging between 3.7% to 35.2%.

**Table 5-17. Route-based analysis of FCW**

| Route | Observed | | 1,000 VMT-Normalized | | Percent Reduction |
|---|---|---|---|---|---|
| | Stealth | Open | Stealth | Open | |
| 1 | 48 | 151 | 9.6 | 8.9 | 7.4 |
| 5 | 3 | 156 | 3.7 | 12.3 | −229.3 |
| 8 | 65 | 119 | 5.8 | 4.2 | 27.8 |
| 16 | 4 | 15 | 1.0 | 4.6 | −344.3 |
| 117 | 20 | 63 | 6.5 | 5.4 | 17.2 |

**Table 5-18. Route-based analysis of UFCW**

| Route | Observed | | 1,000 VMT-Normalized | | Percent Reduction |
|---|---|---|---|---|---|
| | Stealth | Open | Stealth | Open | |
| 1 | 4,431 | 14,500 | 886.2 | 853.7 | 3.7 |
| 5 | 438 | 6,430 | 543.3 | 505.0 | 7.0 |
| 8 | 4,426 | 7,267 | 393.0 | 254.6 | 35.2 |
| 16 | 1,911 | 1,428 | 497.9 | 440.8 | 11.5 |
| 117 | 4,157 | 10,500 | 1,343.4 | 892.0 | 33.6 |

Routes 1 and 16 experienced an increase HWWs, as shown in Table 5-19. The other routes experienced a reduction between 20.5% and 32.2%.

**Table 5-19. Route-based analysis of HWW**

| | Observed | | 1,000 VMT-Normalized | | |
|---|---|---|---|---|---|
| Route | Stealth | Open | Stealth | Open | Percent Reduction |
| 1 | 323 | 1,363 | 64.6 | 80.2 | −24.2% |
| 5 | 80 | 1,001 | 99.2 | 78.6 | 20.8% |
| 8 | 332 | 669 | 29.5 | 23.4 | 20.5% |
| 16 | 104 | 212 | 27.1 | 65.4 | −141.5% |
| 117 | 285 | 735 | 92.1 | 62.4 | 32.2% |

### 5.5.3 Aggressive Braking

The number of FCWs in stealth mode for routes 5 and 117 in Table 5-20 are 3 and 5, respectively. The low number of observations for these two routes makes the conclusions statistically insignificant. The other routes showed reductions ranging between 2.3% and 38.0%.

**Table 5-20. Route-based analysis of AggBrk**

| | Observed | | 1,000 VMT-Normalized | | |
|---|---|---|---|---|---|
| Route | Stealth | Open | Stealth | Open | Percent Reduction |
| 1 | 25 | 83 | 5.0 | 4.9 | 2.3% |
| 5 | 3 | 55 | 3.7 | 4.3 | −16.1% |
| 8 | 35 | 55 | 3.1 | 1.9 | 38.0% |
| 16 | 131 | 108 | 34.1 | 33.3 | 2.3% |
| 117 | 5 | 28 | 1.6 | 2.4 | −47.2% |

### 5.5.4 Summary of Route-based Results

Table 5-21 shows the summary of results for all the warnings. The empty cells in the table are the ones with a low number of observations in stealth mode. Most of the alerts (22 of 26) show a reduction in Table 5-21. Alerts show and average reduction of 19.95%, which is equivalent to a conflict modification factor (CoMF) of 80.05%. If 141% is excluded from the calculations as a possible outlier (due to missing data after May 2019 on Route 16), the average CoMF will be 73.59%.

**Table 5-21. Percent reduction in various alerts**

| Route | PDZ | PCW | FCW | UFCW | HWW | AggBrk |
|---|---|---|---|---|---|---|
| 1 | 74.5% | 11.8% | 7.4% | 3.7% | −24.2% | 2.3% |
| 5 | 56.6% | −4.0% | ---- | 7.0% | 20.8% | ---- |
| 8 | 84.2% | −3.1% | 27.8% | 35.2% | 20.5% | 38.0% |
| 16 | 79.6% | 10.7% | ---- | 11.5% | −141.5% | 2.3% |
| 117 | 89.2% | 25.5% | 17.2% | 33.6% | 32.2% | ---- |

There are two alerts on four routes that showed increase in before-after analysis. The only increases are PCW on routes 5 and 8 and HWW on routes 1 and 16. Table 5-22 shows the number of observed days for each month. As can be seen, Route 5 has five days in stealth mode. Route 8 observed days decrease during the study period. In last 4 months, there were only 12 days of observed data for Route 8.

**Table 5-22. Number of observed days on each route in each month**

| Route | 2019 | | | | | | | | | | | | 2020 | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | |
| **1** | 21 | 12 | 28 | 31 | 4 | ---- | ---- | 8 | 17 | 17 | 14 | 14 | 4 | ---- | **170** |
| **5** | 1 | 4 | 1 | 6 | 27 | 28 | 13 | 8 | 1 | ---- | 1 | 3 | 1 | ---- | **94** |
| **8** | 27 | 32 | 25 | 35 | 18 | 16 | 16 | 16 | 15 | 16 | 8 | 3 | ---- | 1 | **228** |
| **16** | 14 | 12 | 8 | 14 | 1 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | **49** |
| **117** | 14 | 11 | ---- | 8 | 1 | ---- | ---- | 8 | 15 | 18 | 13 | 6 | 13 | 15 | **122** |
| **Mode** | **Stealth** | | **Open** | | | | | | | | | | | | |

# Chapter 6 – Hotspot Analysis

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The purpose of this section is to identify potential risk factors for high conflict locations. Ituran includes a visualization tool that shows locations with high conflicts, called hotspots in this study. Figure 6-1 shows the hotspots from the Ituran Web interface. In this figure, locations with highest conflict alert observations are indicated with pink color and lowest with yellow.

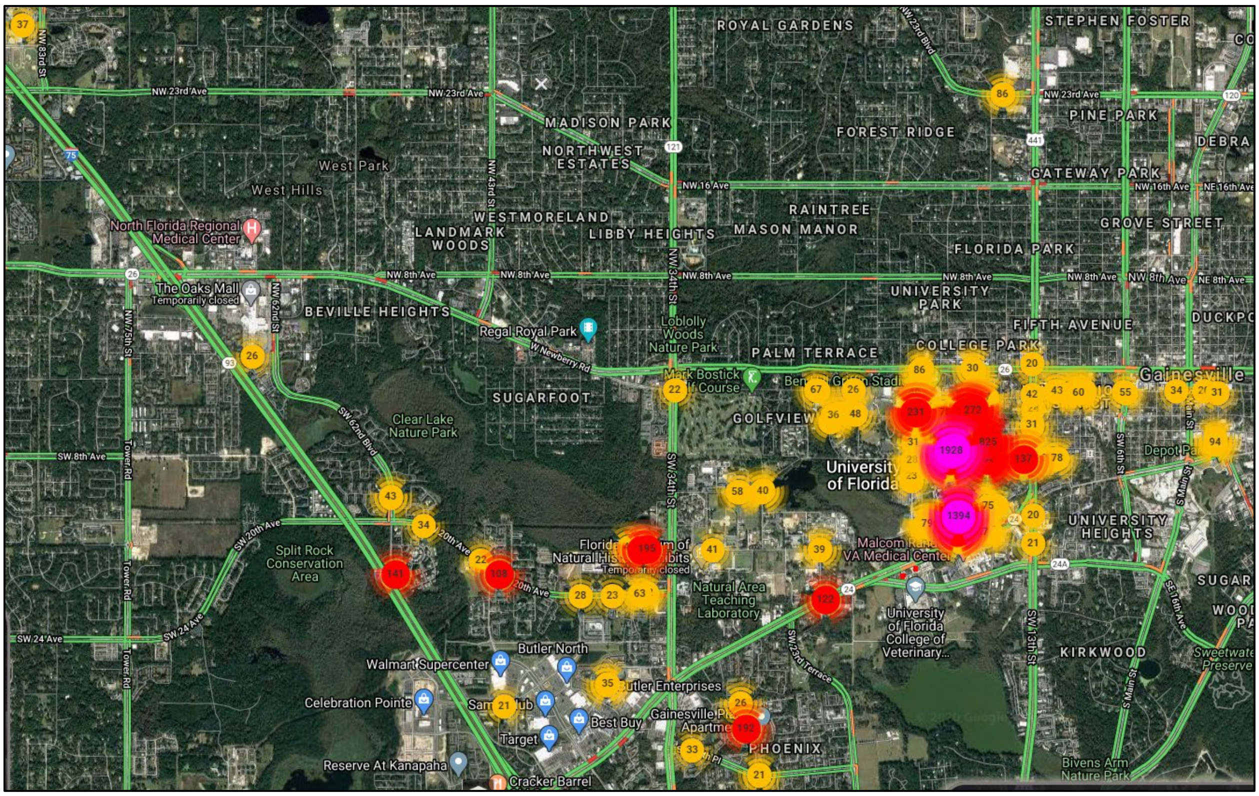


**Figure 6-1 – Ituran hotspots**

It was observed that most of the hotspots were locations with high pedestrian demand but not with severe risk factors, and because the purpose of this study is find locations with high risk factors in the network, we developed a normalization methodology. This methodology focuses on finding locations that have a higher ratio of PCW to PDZ. Here, PDZ is considered as an exposure measure. Ituran does not have a feature to rank the locations with a selected measure. So, an algorithm was developed in R to rank the locations and produce graphical output.

## 6.1 PDZ-normalized Hotspots

The purpose of the normalizing methodology was to find locations with severe risk factors that also have high demand. For this goal, the Gainesville map was divided into 400 horizontal and 400 vertical bins (160,000 bins). In each bin, the numbers of PCWs and PDZs were found, and the ratio of PCW to PDZ was calculated. This ratio is named PCW density. For visualization purposes, a heatmap of the PCW density was plotted, as shown in Figure 6-2. It is obvious that the locations highlighted are scattered all over the map. So, these locations are not the ones with just high demand.

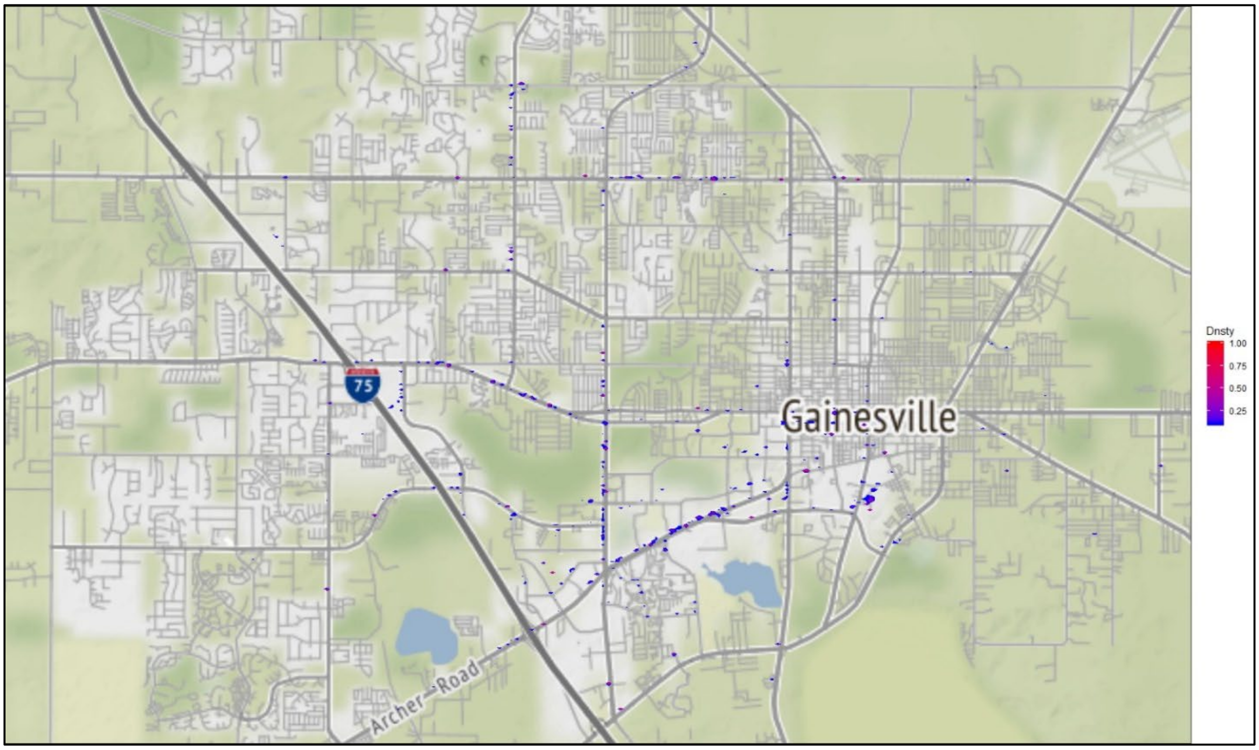


**Figure 6-2 – PCW density heatmap**

Figure 6-3 shows PDZ, PCW, and PCW density heatmap using a grid of 100×100 bins. As shown, PCW and PDZ heatmaps are similar. The density risk heatmap shows the hotspots that possibly have more risk factors – significantly more locations are identified using the heatmap.

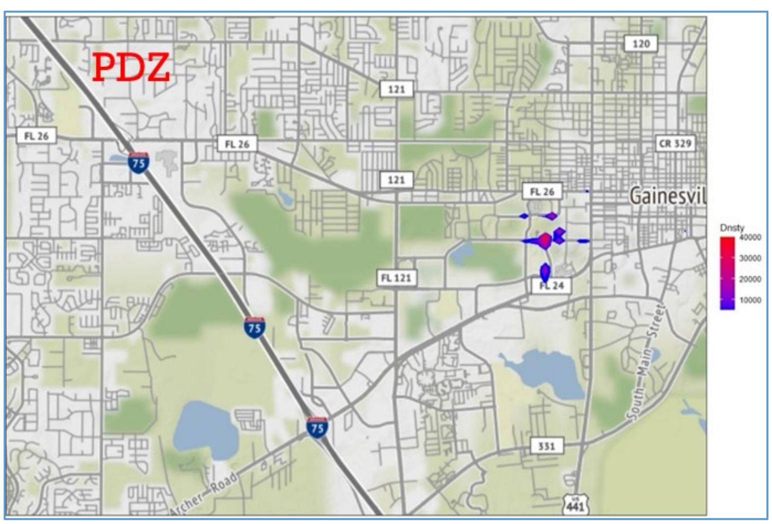


**Figure 6-3 – Density heatmaps (100×100): (a) PDZ**

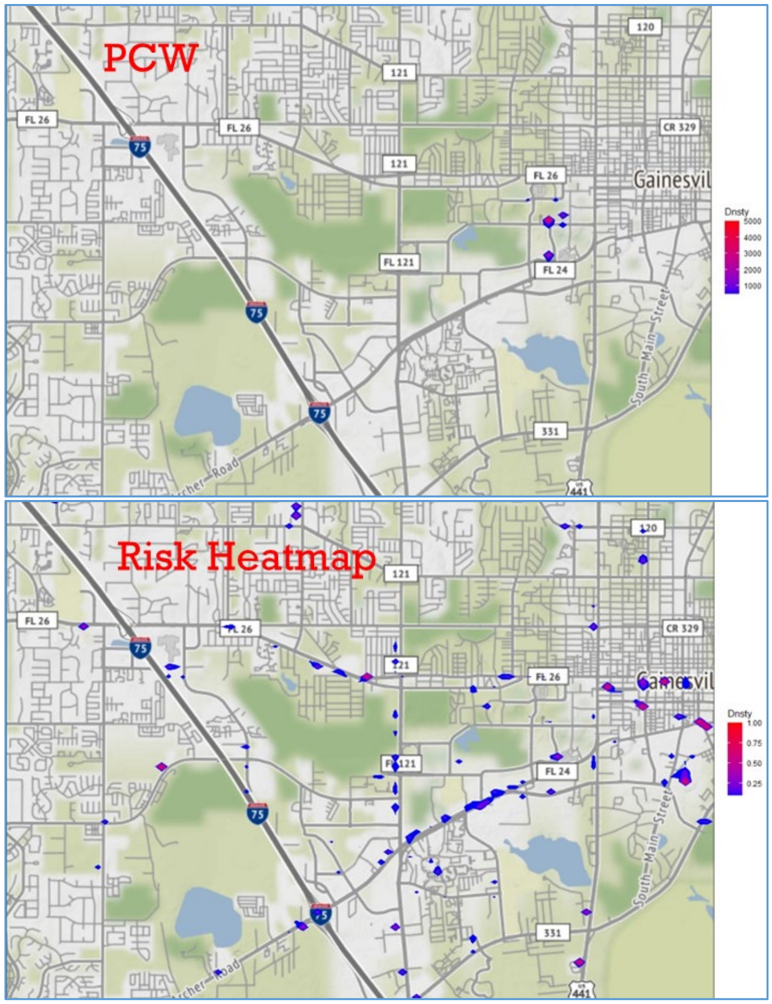


**Figure 6-3 – Density heatmaps (100×100): (b) PCW; (c) PCW**

## 6.2 Hotspots

The hotspots in this section are locations that (1) have more than five pedestrian collision warnings in the data collection period and (2) have a PCW density more than 0.2. Using the mentioned filters, 21 hotspots were found. When adjacent hotspots were combined as one (three clusters with 3, 2, and 2 hotspots, respectively), 17 hotspots remained for further review. Of these 17 hotspots, three were locations with high pedestrian demand and few severe risk factors: the RTS bus depot, Santa Fe College, and Walmart. These three locations are shown in Figure 6-4. Excluding these three locations left 14 hotspots for further review.

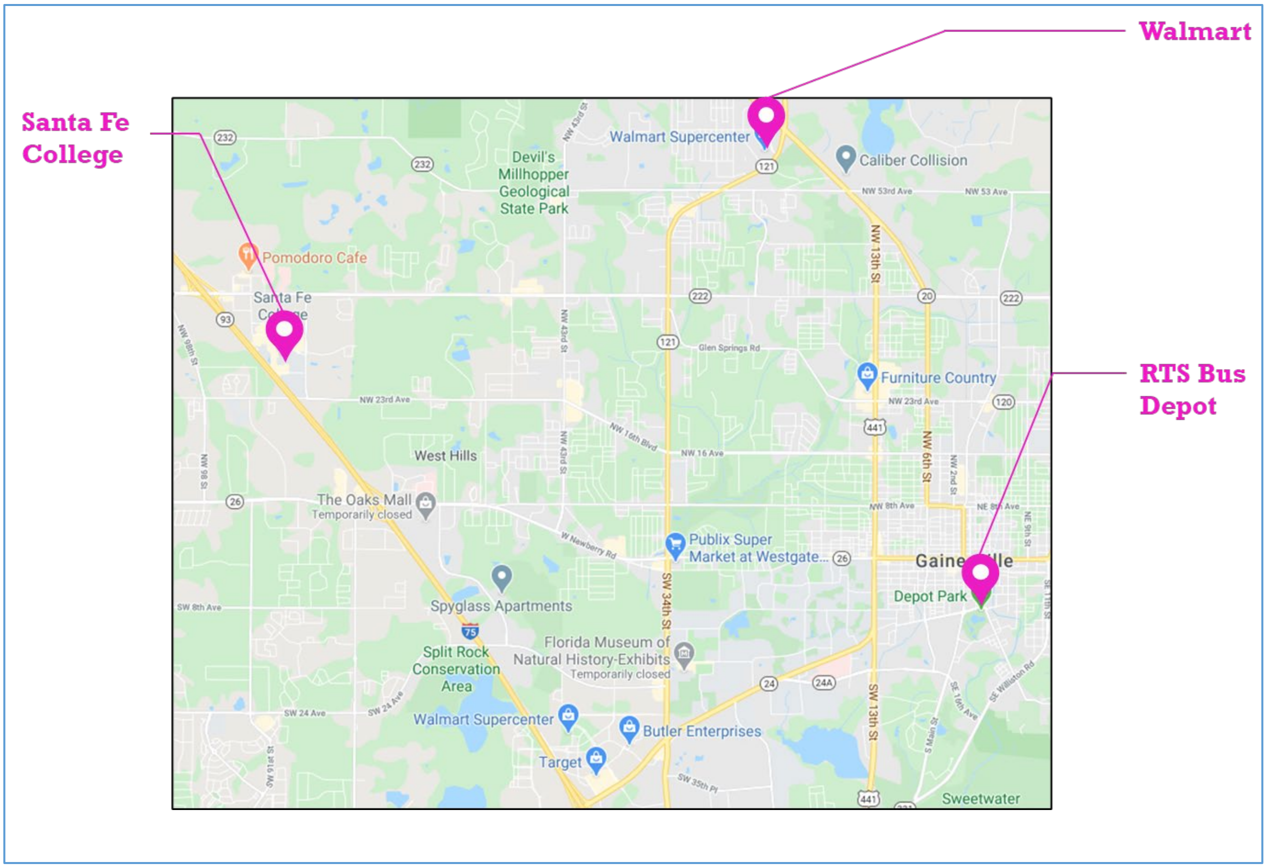


**Figure 6-4 – Hotspots with high pedestrian demand and few severe risk factors**

The 14 hotspots exhibited obvious risk factors. As indicated in Figure 6-5, three of these locations were roundabouts. Two of the roundabouts, 1-1 and 1-2, are in residential areas, implying relatively high pedestrian demand. The next hotspot in Figure 6-5 is close to Shands Hospital and also has high pedestrian demand. This location is a 3-leg intersection that is close to three curves on its legs. From field review, it was evident that there was a surge in pedestrian exposure due to the parking lot SW of this intersection.

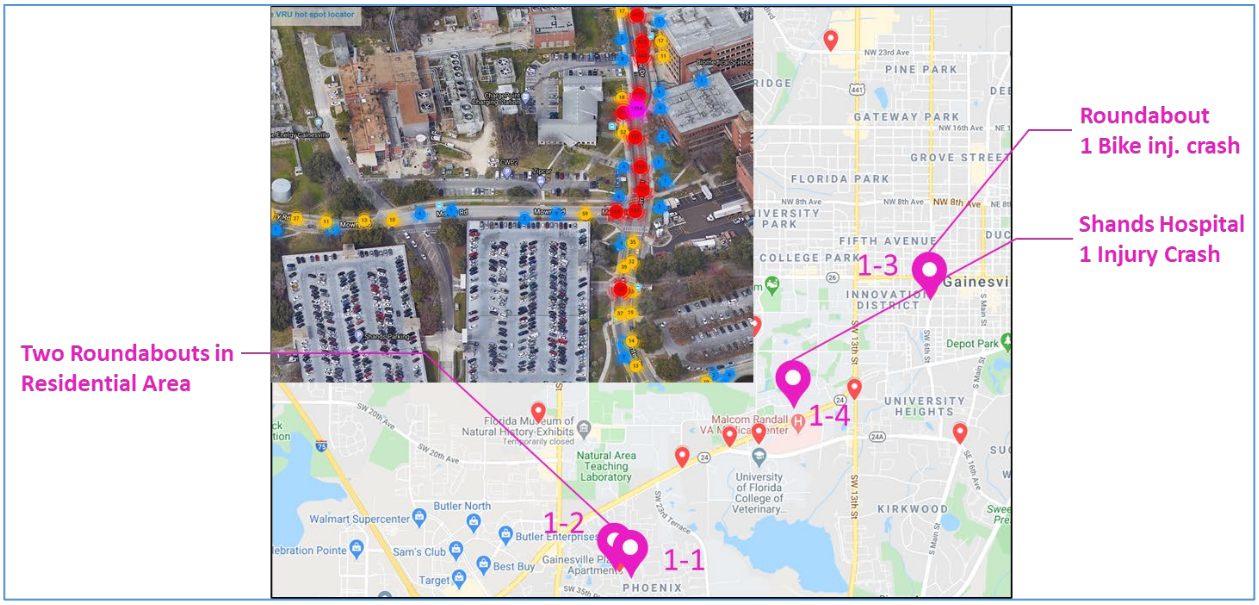


**Figure 6-5 – Hotspots 1: three roundabouts and Shands Hospital**

Figure 6-6 shows the next six hotspots. At hotspot 2-1, indicated in Figure 21 and shown in an aerial view in Figure 6-7, there is a bus stop between two closely located intersections. At Hotspot 2-2, there is a bus stop on a curve that is located close to parking lots on both sides of the road. An aerial view of hotspot 2-2 is shown in Figure 6-8.

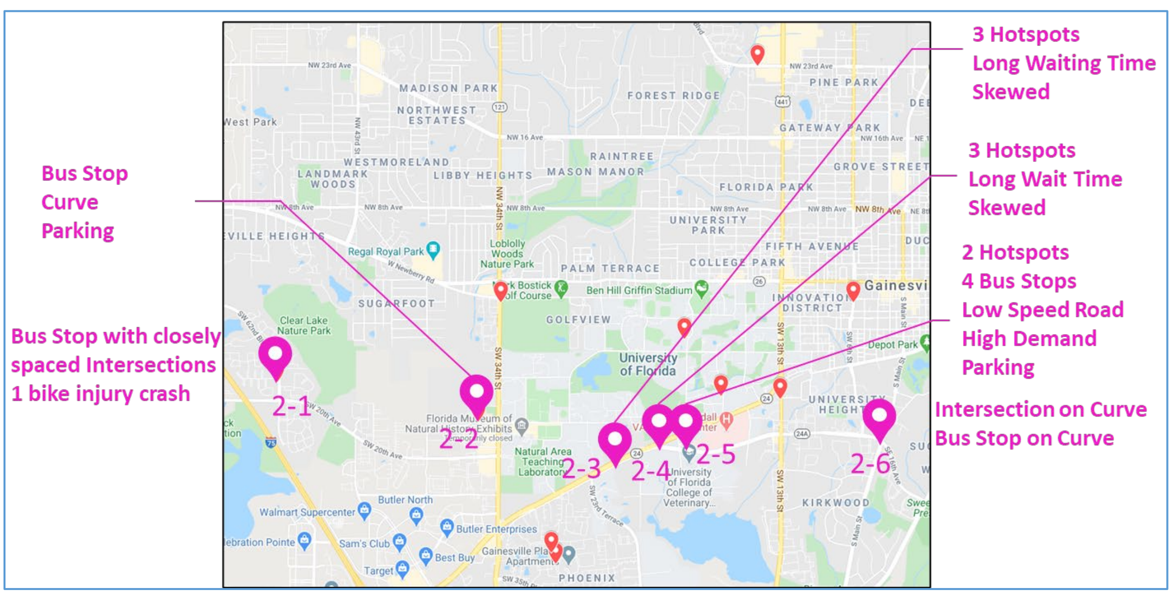


**Figure 6-6 – Hotspots 2: Set of 6 hotspots**

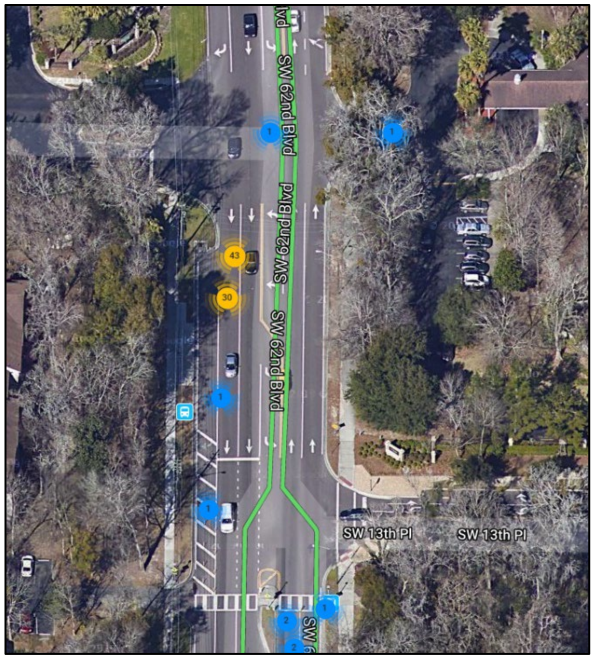


**Figure 6-7 – Aerial view of hotspot 2-1**


**Figure 6-8 – Aerial view of hotspot 2-2**

Hotspot 2-3 is at a skewed intersection, as shown in Figure 6-9. This hotspot is the aggregate of three hotspots. There is a long waiting time for the pedestrians who want to cross Archer Road. Hotspot 2-4 (aerial view in Figure 6-10) is located close to 2-3; its risk factors are similar to 2-3.


**Figure 6-9 – Aerial view of hotspot 2-3**


**Figure 6-10 – Aerial view of hotspot 2-4**

Hotspot 2-5 (aerial view in Figure 6-11) is the aggregation of two hotspots. This location is a low speed road, but with high pedestrian demand. There are four bus stops close to each other in adjacent of a parking lot. At hotspot 2-6, there are two bus stops adjacent to an intersection on curve, as shown in Figure 6-12.


**Figure 6-11 – Aerial view of hotspot 2-5**


**Figure 6-12 – Aerial view of hotspot 2-6**

Figure 6-13 shows the last four hotspots. The aerial views of these hotspots are shown in Figure 6-14 to Figure 6-17. Hotspot 3-1 is located at an intersection with speed limits of 35 and 45 mph. These speeds are higher than its vicinity on campus. Hotspot 3-2 is on campus with high demand. There is a bus stop on a reverse curve adjacent to a parking lot. Hotspot 3-3 includes a bus stop in between of two intersections. There is a change in the road geometry from undivided to divided. Hotspot 3-4 is close to a branch of Shands Hospital, a gym, and a parking lot.

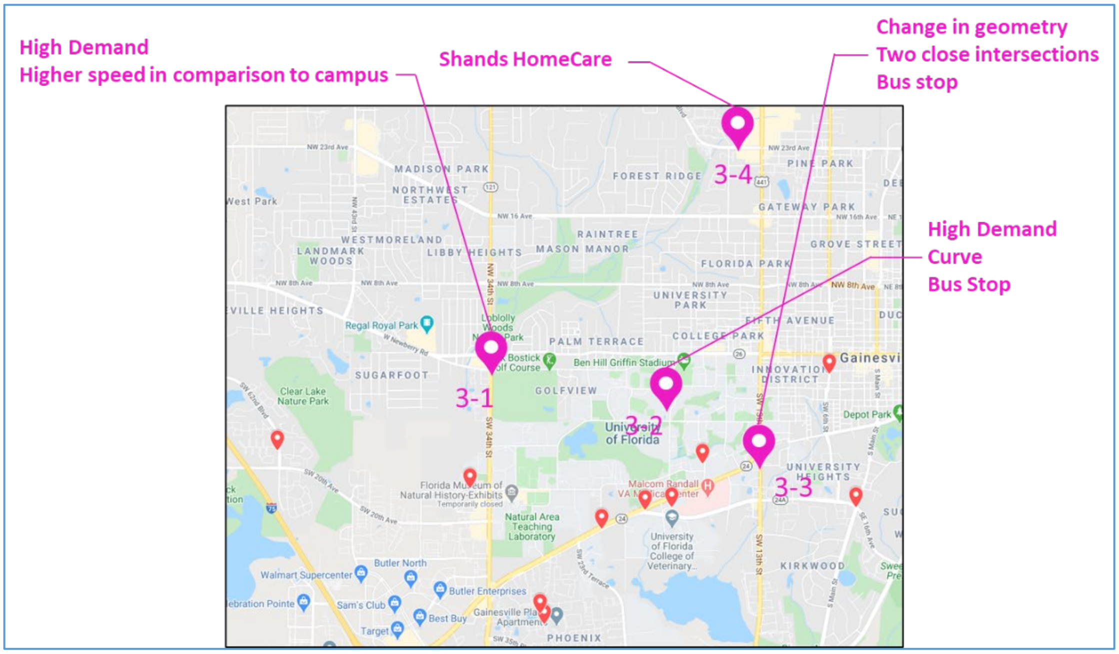


**Figure 6-13 –Hotspots 3: Set of four hotspots**

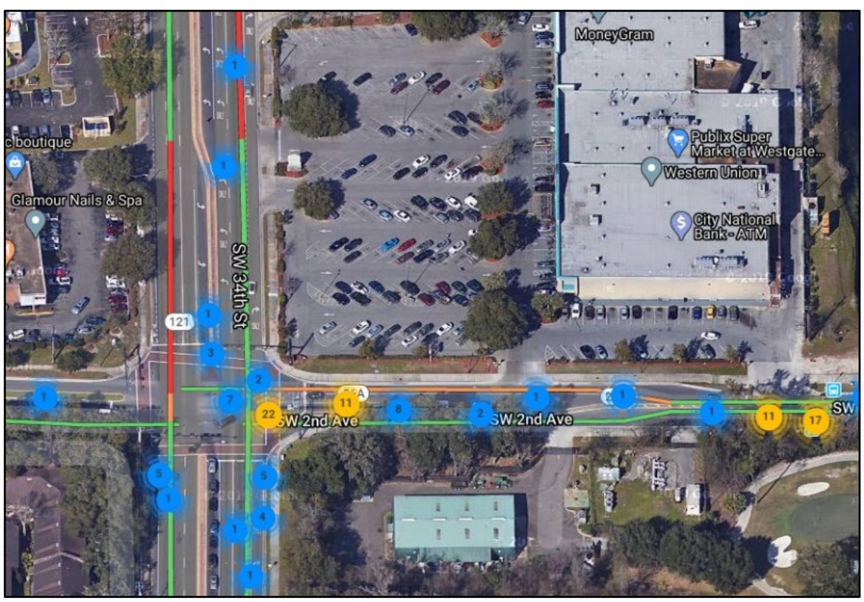


**Figure 6-14 – Aerial view of hotspot 3-1**

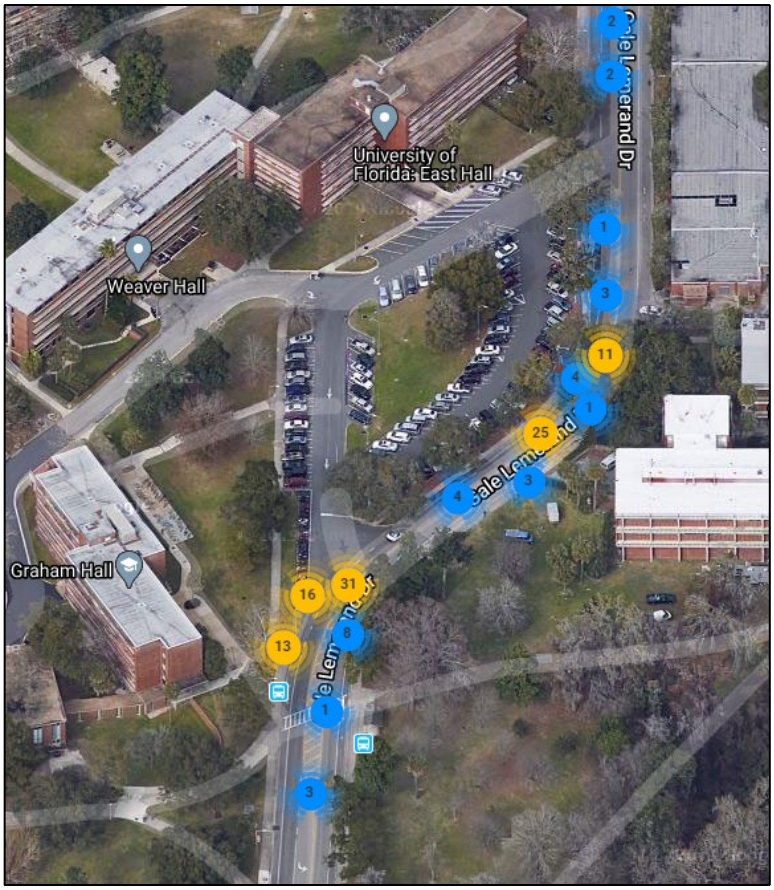


**Figure 6-15 – Aerial view of hotspot 3-2**

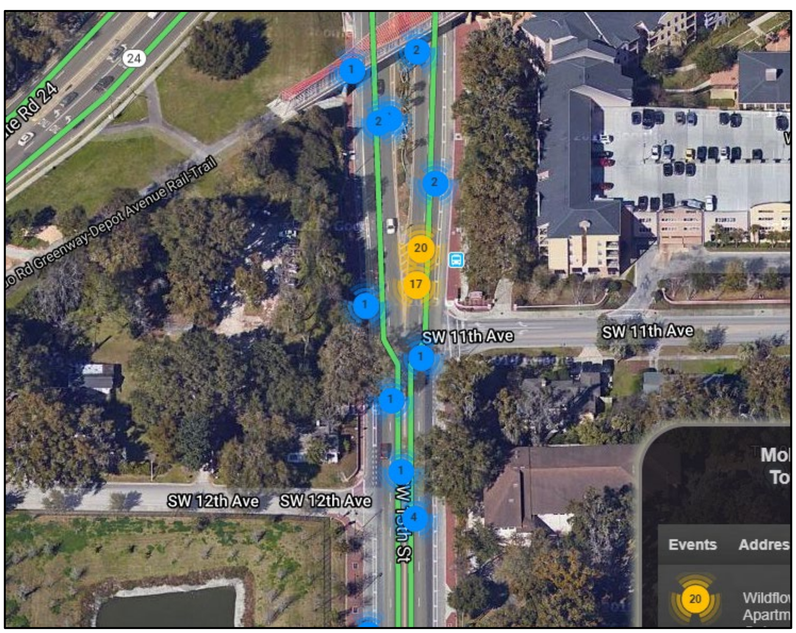


**Figure 6-16 – Aerial view of hotspot 3-3**

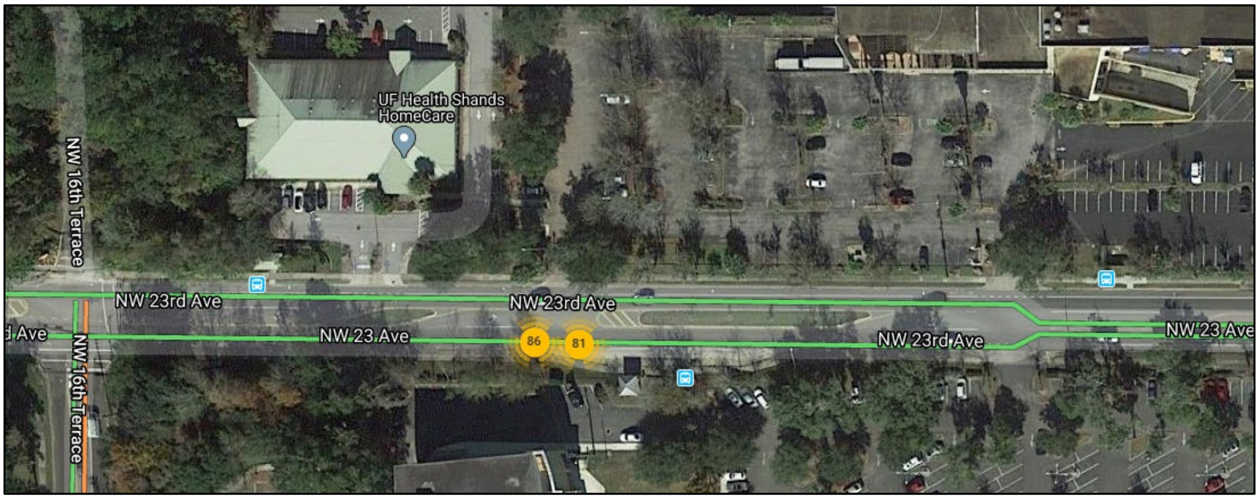


**Figure 6-17 – Aerial view of hotspot 3-4**

Table 23 summarizes the risk factors and information about the 14 hotspots. The overall observations are as following:

- Alignment: Curves
- Intersections: Signalized, roundabouts, offsets, Y-intersections
- Facilities: Bus stops, crosswalks
- Land use: Parking, residential, commercial, campus
- Pedestrian signal timing: Ped phase time

**Table 6-1. Summary of hotspot risk factors**

| | | | | | | | | Intersection | | | Land Use | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Density Rank | Location | Density | PCW | PDZ | Bus stop | Curve | Round-about | Regular | Skewed | Stag-gered | Parking | Resi-dential | Com-mercial | Campus | Demand | Additional Comments |
| 1 | 1-4 | 0.2172 | 1,209 | 5,567 | X | X | | X | | | X | | | X | XXX | Shands Hospital |
| 2 | 1-2 | 0.3115 | 566 | 854 | X | X | X | | | | X | | | | XX | Bus stop at roundabout |
| 3 | 2-2 | 0.3798 | 226 | 595 | X | X | | | | | X | | | | X | Bus stop a curve parking |
| 4 | 3-4 | 0.2320 | 87 | 375 | X | X | | | | | X | | X | | XX | UF Health |
| 5 | 2-1 | 0.2694 | 59 | 219 | X | X | | X | | X | | X | | | X | Bus stop at a staggered intersection |
| 6 | 2-3 | 0.2196 | 56 | 255 | X | | | X | X | | | X | | X | X | 3 hotspots; long pedestrian weighting time |
| 7 | 1-3 | 0.2283 | 51 | 92 | | | X | | | | X | X | | | X | Roundabout |
| 8 | 3-2 | 0.2985 | 20 | 67 | X | X | | | | | | | | X | XX | High demand bus stop at curve |
| 9 | 2-5 | 0.2683 | 22 | 82 | X | X | | | | | X | X | | | | Three bus stops, low speed designed road |
| 10 | 3-3 | 0.2075 | 11 | 53 | X | | | X | | | | | | | | Change in road geometry |
| 11 | 2-4 | 0.3400 | 17 | 50 | | | | | X | | | X | | | X | Highly skewed intersection |
| 12 | 2-6 | 0.2063 | 9 | 43 | X | X | | X | | | | | | | | Intersection on curve |
| 13 | 3-1 | 0.3182 | 7 | 22 | X | | | X | | | | | X | | | Higher skewed intersection |
| 14 | 1-2 | 0.2222 | 6 | 27 | | | X | | | | | X | | | | Intersection on curve |

# Chapter 7 – Operator Focus Groups

Five focus group sessions were held to elicit responses from bus drivers who had experienced the Mobileye Shield+ (MS+) advanced driver assistance system (ADAS). There were four drivers scheduled for each of the sessions. The table below provides the schedule of focus group interviews.

**Table 7-1. Focus groups with drivers of ADAS-equipped drivers**

| Focus group number | Date | Time | Number of participants |
|---|---|---|---|
| 1 | 7/10/2020 | 8:00 am | 3 |
| 2 | 7/10/2020 | 9:00 am | 4 |
| 3 | 7/10/2020 | 11:00 am | 4 |
| 4 | 7/13/2020 | 1:00 pm | 4 |
| 5 | 7/13/2020 | 2:00pm | 3 |

The facilitator invited responses to a series of nine anchor questions:

1. How familiar are you with the Shield+ system?
2. What positive and negative experiences did you have while operating the vehicle with the Shield+ system?
3. What visual and audible alerts of the Shield+ system did you find to be most helpful?
4. Did you feel that the Shield+ system improves safety?
5. Have you experienced any false alarms where there were no risk factors like pedestrians or vehicles around? If so, explain the situation and how frequently it happened?
6. What would you think of a system that automatically applied the brakes during an emergency situation?
7. If you could make one change that would make the system better, what would you suggest?
8. What was your comfort level with the system?
9. Would you prefer driving a bus with Shield+ system? Why?

The questions provided opportunities for the drivers to report many aspects of their experience with the MS+ system. Generally, drivers seemed relaxed, cooperative, and talkative in the focus group sessions.

Major themes of the sessions included the following and are detailed in the summaries below:

- Drivers encountered the system without training or preparation. In many cases, they did not know the expected functioning of alerts and had to interpret their function from observation. In some cases, lack of training – and therefore expectation – made it impossible for drivers to detect a dysfunctional alert.

- Drivers generally reported too many alerts, alerts for no apparent reason (false alerts), alerts for stationary objects (false positive alerts), and no alert when pedestrian present (false alerts).

## 8.1 – 1. How familiar are you with the Shield+ system?

### Familiarity:

Drivers were very familiar with the system, and many had 8–12 work weeks of experience with the system. Some drivers in the last session reported a lack of training and a lack of knowledge of specific MS+ functions or a general overview of the system. This occurred in the last session; training was not discussed in other sessions.

### Routes mentioned:

RTS Bus routes: 1, 20, 34, 46, 35, 10, and 38

Drivers clarified that that they were usually assigned to a route, but the bus for that route might differ from day to day.

## 8.2 – 2. What positive and negative experiences did you have while operating the vehicle with the Shield+ system?

### Positive:

Most drivers felt that the alerts are useful, especially if someone was near the bus. Some stated that the alerts helped get the driver’s attention. Some said that they felt it improved safety.

Some drivers found the system most useful on the University of Florida campus where there are many students and increased congestion levels.

### Negative:

Some drivers seemed to have encountered the system without any preparation. They reported that they did not know what it was at first; they just heard the beeping and figured it out from there.

Many drivers reported that system sometimes gave alerts for no apparent reason or that they could not tell what the system was responding to.

Some drivers felt that the alerts were very loud. One driver described the alerts as “scary.”

Drivers had mixed experience with the visual pedestrian warning. For some, the warning never changed color, and they could not understand its purpose. Several drivers reported that they did not see red, yellow, and green pedestrian warnings. Some drivers saw only a green warning; some drivers saw only green or red, never yellow.

Some drivers reported that the system gave no alert when a pedestrian or bicyclist was too close to the bus. Some drivers reported that they received no alert when a pedestrian crossed in front of the stopped bus.

Some drivers were concerned that the system does not operate in the dark at a time when they felt it might be most useful.

Many drivers reported that the system provided alerts too frequently, especially on campus, to the point that it became unhelpful or distracting.

One driver felt that the system alert sounds were too similar to other bus alarms.

## 8.3 – 3. What visual and audible alerts of the Shield+ system did you find to be most helpful?

The following table shows the approximate ranking given by the respondents. Not all respondents ranked all five warnings. Respondents were not asked about the speed warning; they volunteered that it was helpful. Respondents did not distinguish between high speed and low speed collision warnings.

**Table 7-2. Mobileye Shield+ alerts ranked by bus drivers**

| ADAS warning | Rank (Rank 5 indicates most helpful) | | | | | Weighted rank |
|---|---|---|---|---|---|---|
| | **5** | **4** | **3** | **2** | **1** | **----** |
| Pedestrian | 13 | 2 | 3 | ---- | ---- | **4.6** |
| Headway | 1 | 5 | 8 | 1 | ---- | **3.4** |
| Speed | 2 | 1 | 3 | ---- | 1 | **3.4** |
| Lane Departure | 1 | 2 | ---- | 5 | 3 | **2.4** |
| Collision | ---- | 5 | ---- | 1 | 1 | **3.3** |

## 8.4 – 4. Did you feel that Shield+ system improves safety?

Respondents were asked to answer yes or no. Not all respondents answered.

**Table 7-3. Bus driver attitudes about whether Mobileye Safety+ improves safety**

| Respondent answer | Number of answers |
|---|---|
| Mobileye Shield+ improves safety | 13 |
| Mobileye Shield+ does not improve safety | 4 |

## 8.5 – 5. Have you experienced any false alerts where there were no risk factors like pedestrians or vehicles around? If so, explain the situation and how frequently it happened?

Most drivers reported false alerts; some had many. The false alerts were in two categories: system alerts when no apparent object and system alerts for stationary object (trash can, trees, signs, the curb).

One driver reported that the speed readout on the MS+ did not agree with the bus's speedometer, i.e., the MS+ gave the wrong speed. In another group, two drivers reported defective speedometers on their buses and found the MS+ system helpful.

Drivers reported that receiving an alert when no apparent object was present was especially distracting because of the attention needed to search and verify that there was no object along with other mechanical warnings already installed on the bus.

## 8.6 – 6. What would you think of a system that automatically applied the brakes during an emergency situation?

Respondents were asked to answer yes or no. Not all respondents answered. In some groups, there was a lively discussion of the pros and cons of automatic braking. In some cases, these discussions led drivers to imagine a system they would accept. Several drivers referenced automatic braking to similar systems in their cars or the cars of friends. Drivers in one session discussed a current feature of their buses, the retarder, that actively slows the bus when they driver removes their foot from the gas pedal – a feature they generally liked. A concern of many drivers was the danger to passengers if the bus was braked too abruptly. One driver had medical issues that would be aggravated by sudden stopping. In one session, drivers discussed the option of avoiding objects at the last second, which would not be possible if the bus was braked automatically – drivers in other sessions had hinted at this without expressing it so clearly. Drivers were concerned about automatic braking on roads like Archer Rd, a congested multilane road, where they are frequently cut off by drivers seeking to make turns; they felt that this would lead to excessive braking. One driver supported an automatic braking system because it would prevent crashes.

Some drivers, considering passenger safety, suggested that such a system could be tested in a low speed setting like the campus where the speed limit is 20 mph; other drivers were concerned that the system would activate too often, considering the number of bicycles and pedestrians. Drivers referred to the need to move forward very slowly through crowded crosswalks to protect pedestrians while still making headway.

**Table 7-4. Bus driver preferences regarding automatic braking systems**

| Respondent answer | Number of answers |
|---|---|
| I do would like an automatic braking system in my bus. | 1 |
| I do would like an automatic braking system in my bus **if it worked a certain way**. | 3 |
| I do would **not** like an automatic braking system in my bus. | 13 |

## 8.7 – 7. If you could make one change that would make the system better. What would you suggest?

Most comments concerned false alerts and the sensitivity of the MS+ system.

Drivers were also concerned with the failure to alert – on one hand, the system might give alerts for stationary or nonexistent objects; on the other hand, it might fail to alert if a pedestrian, bicyclist, or car was too close to the bus. In general, drivers reported false positive alerts much less frequently than false negative alerts.

One driver suggested that the system should be more sensitive in the front than the back so that pedestrians or bicycles that were attempting to cross in front of the bus could not be missed.

Some drivers suggested that the system would be more useful if it worked in the dark. Some drivers begin their routes at 5 AM, and the system does not work until daylight.

Several drivers commented on the need for the system to give better information about why it is giving an alert. Some drivers wanted the system to give better information about the location of the pedestrian or bicyclist causing an alert. Others mentioned an interest in a better camera system so that they could see what the system was responding to. These comments corresponded to driver concerns that an alert would force them to spend time looking for a cause, and that process should take less of the driver's time and attention.

One driver wanted the system readouts to be mounted in a higher location in the bus. The system was mounted on the dash, out of the driver's general field of vision. The driver mentioned that taking eyes off the road to look down at the dash at critical moments was not safe.

A few drivers referred to the lack of training or not knowing the features and capabilities of the MS+ system. In sessions where this came up, even drivers without this concern could not confirm that they had received any training or informational material. Therefore, drivers in all sessions may have been responding from very uneven understandings of what they were seeing and hearing from the system. Combine this with the variation in system repair and operation that some drivers reported, which are otherwise not documented.

## 8.8 – 8. What was your comfort level with the system?

Most drivers were generally comfortable with the system, once they got used to it, and found it helpful. A few drivers did not like the system or preferred not to rely on this technology. Many drivers again discussed the sensitivity problem of not receiving alerts when they should or receiving alerts when they should not.

Drivers also discussed where the system is most useful. A limited number of drivers felt that the system should not operate in very congested pedestrian environments like the University of Florida campus; more commonly, drivers wanted to use the system on campus where foot and bicycle traffic volume is greatly increased, in the words of one driver, as "another pair of eyes." Some drivers felt that the system was less useful on community roads where the bus is less likely to encounter a pedestrian or bicyclist; others saw this as the reason to have the system on community roads.

A few drivers felt that the system was more of a distraction. One used the word "erratic." Some drivers gave a conditional response: "if they could fix what's wrong with it", "if they could work out the kinks," etc. The few drivers with the conditional responses were referring to the false alerts of inanimate objects on the roadway, sidewalks, bus loops, and infrastructure that does not move.

## 8.9 – 9. Would you prefer driving a bus with Shield+ system? Why?

Most drivers preferred having the MS+ system on the bus. They repeated that the system has sensitivity problems. One driver was concerned about having more alarms in the loud environment of a bus where there are already a number of systems that sound alarms. Some drivers commented that they like the extra sense of safety that the system provided.

Some drivers were definitely opposed to having the MS+ system on their bus. One said that the system was too “aggressive.” Others said that it depended on the bus route.

Most drivers agreed that the system needs improvement, mainly associated with false alarms. However, majority of drivers interviewed prefer to drive a bus with the system installed, as is.

# Chapter 8 – Benefit-Cost Analyses

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This section documents the benefit-cost analysis tool that was developed based on the data gathered on the advanced driver assistance system. The tool was developed in a macro-enabled Excel spreadsheet. This Excel spreadsheet tool is delivered as a supplement to this word document: “ADAS-BC_Analysis.xlsm.”

## 8.1 Tool Inputs and Outputs

The tool input parameters include transit data, safety information, and monetary values of crash and investments. Using the input information and predefined values for conflict conversion factors, the tool computes the net benefit and benefit-to-cost ratio. The output is per bus with ADAS system installed. Figure 8-1 shows the user interface of the spreadsheet-based tool.

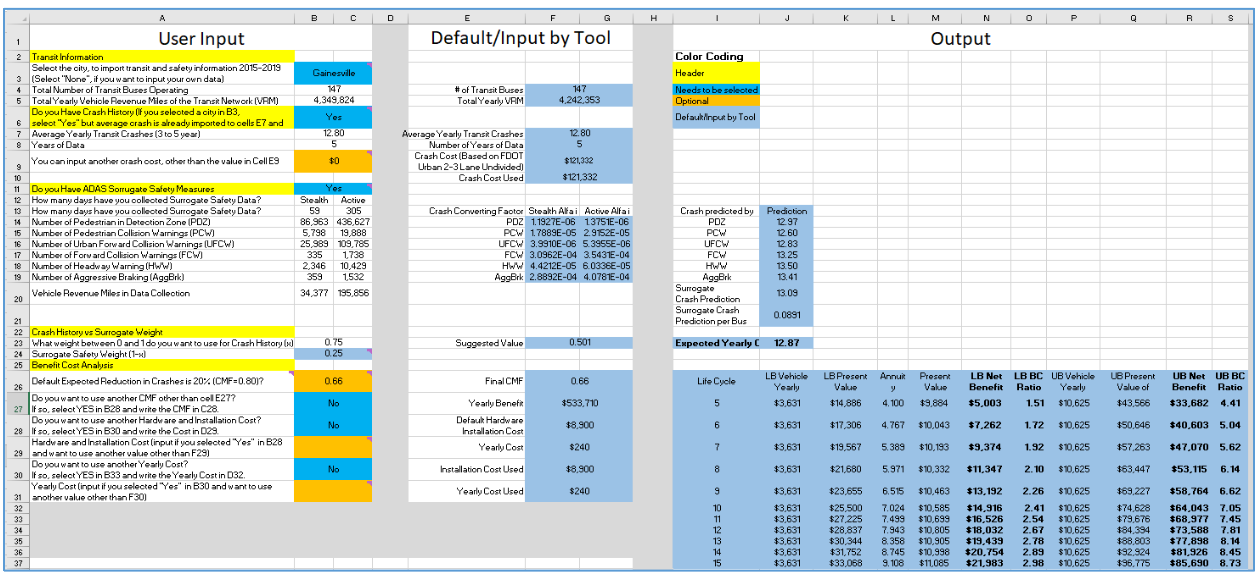


**Figure 8-1 – Benefit-cost analysis tool’s user interface**

The tool also provides two visual outputs: net benefit and benefit-to-cost ratio diagrams as shown in Figure 8-2. The lower bound (LB) and upper bound (UB) are shown in these two diagrams, based on the life cycle of the system. As with every investment, the longer the service life, the higher the return. Practically, the true values fall in between the LB and UB, and these bounds assists the analyst in using their engineering judgement to decide if the investment is warranted.


**Figure 8-2 – Visual output of the tool**

## 8.2 User Input

There are two user input sections: transit information and safety analysis section.

### 8.2.1 Transit Information

In this section, the user supplies information about the number of transit buses and total yearly vehicle revenue miles (VRM) travelled. This information is used as input in the subsequent sections to estimate the surrogate predicted number of crashes and estimating the expected number of crashes. In the tool, the user can select any of the 28 transit agencies in Florida. These 28 agencies were selected based on the data available from the National Transit Database (2019). When the user selects the transit agency, the tool imports the transit information and the five-year history of crashes for further calculations.

### 8.2.2 Safety Analysis

The safety analysis includes utilizing the historical crashes, surrogate safety measures collected by the Mobileye Shield+ system, and estimating the expected number of crashes.

#### *8.2.2.1 Historical Crashes*

In order to quantify the safety performance, the historical crash data are critical. In this tool, if the user has the crash data available, the user can input the yearly average of transit crashes for the past 3–5 years. If the user does not have the data available, the user can select the city from available options to import the average yearly transit crashes between 2015 and 2019. These crash data were prepopulated using the NTD database.

#### *8.2.2.2 Surrogate Safety Predictions*

One of the major limitations for a robust transit-related crash analysis is the low crash numbers, which decreases the statistical significance because a slight change in number skews the results considerably. As an alternative, this study adopted safety risk analysis based on exposure data collected in the field. This study developed a platform to use the exposure from the Mobileye Shield+ system to estimate the predicted number of transit crashes. Table 1 shows the total number of alerts recorded by the Mobileye system for the study period.

**Table 8-1. Total alerts data compiled using Mobileye Shield+ through 14 months**

| Year | Month | Alert | | | | | | Miles |
|---|---|---|---|---|---|---|---|---|
| | | PDZ | PCW | UFCW | FCW | HWW | AggBrk | |
| 2019 | Jan | 43,466 | 2,665 | 10,999 | 117 | 822 | 182 | 11,780 |
| | Feb | 43,497 | 3,133 | 14,990 | 218 | 1,524 | 177 | 22,597 |
| | Mar | 43,525 | 1,657 | 10,486 | 152 | 1,080 | 213 | 18,235 |
| | Apr | 43,556 | 2,501 | 9,612 | 197 | 1,043 | 192 | 22,429 |
| | May | 43,586 | 1,155 | 9,553 | 250 | 1,314 | 224 | 20,722 |
| | Jun | 43,617 | 1,027 | 9,716 | 284 | 1,382 | 165 | 19,249 |
| | Jul | 43,647 | 954 | 7,109 | 215 | 882 | 206 | 17,698 |
| | Aug | 43,678 | 2,286 | 13,752 | 173 | 1,063 | 105 | 19,853 |
| | Sep | 43,709 | 3,503 | 15,513 | 137 | 1,031 | 68 | 20,549 |
| | Oct | 43,739 | 3,138 | 13,501 | 110 | 868 | 90 | 22,029 |
| | Nov | 43,770 | 2,587 | 12,759 | 124 | 952 | 111 | 18,809 |
| | Dec | 43,800 | 1,080 | 7,784 | 96 | 814 | 158 | 16,283 |
| 2020 | Jan | 43,831 | 2,434 | 11,062 | 119 | 696 | 96 | 23,197 |
| | Feb | 43,862 | 2,411 | 12,787 | 178 | 825 | 140 | 19,916 |
| | Total | 611,283 | 30,531 | 159,623 | 2,370 | 14,296 | 2,127 | 273,345 |

#### *8.2.2.3 Conversion Methodology from Surrogate Safety to Predicted Crashes*

In the absence of long term high frequency crash numbers, the objective is to identify a surrogate safety assessment method. The purpose of this step is to find conversion factors (CFs) between the observed conflicts from the buses, including ADAS and observed crashes. For this goal, all transit crashes were normalized to the total vehicle revenue miles (VRM). The correct way of finding the CFs is to correlate each type of conflict to the same type of crash. However, the National Transit Database does not define the crash type (vehicular, pedestrian, etc.). As a result, each conflict was correlated to all types of crashes. For each surrogate safety measure, a CF was computed through the following formula:

$$\frac{\text{Avg Yearly Transit Crash}}{\text{City Transit VRM}} = \text{CF}_i \times \frac{(\text{Observed Conflicts})_i}{\text{ADAS VRM}} \tag{8-1}$$

$i$ = Conflict number
Avg Yearly Transit Crash = Yearly average of transit crashes in the city
City Transit VRM = The city transit network vehicle revenue miles
$CF_i$ = Conversion factor to convert conflicts to equivalent crashes
Observed Conflicts = Number of observed conflicts of type i
ADAS = Advance driver assistance system (Mobileye Shield+)
ADAS VRM = VRM travelled by ADAS from data collection

The numbers in Table 1 were collected in Gainesville, Florida, between January 2019 and February 2020. The average yearly transit crash in this city based on NTD for years 2015–2019 was 12.8 crashes per year. Using the mentioned numbers and the formula above, the following CFs were found, Table 2. This table includes CFs for both stealth and active mode of Mobileye Shield+ system for various conflicts.

**Table 8-2. Surrogate safety to predicted crash conversion factors (CFs)**

| Alert | Stealth CF | Active CF |
|---|---|---|
| PDZ | 1.1927E-06 | 1.3751E-06 |
| PCW | 1.7889E-05 | 2.9152E-05 |
| UFCW | 3.9910E-06 | 5.3955E-06 |
| FCW | 3.0962E-04 | 3.5431E-04 |
| HWW | 4.4212E-05 | 6.0336E-05 |
| AggBrk | 2.8892E-04 | 4.0781E-04 |

Consider a situation that collected data needs to be used for predicting crashes using the collected conflict data through Mobileye Shield+. By using formula (8-1), with simple calculations formula (8-2) is achieved:

$$\text{Avg Yearly Transit Crash} = \text{CF}_i \times \frac{(\text{Observed Conflicts})_i}{\text{ADAS VRM}} \times \text{ City Transit VRM} \quad (8\text{-}2)$$

Formula (8-2) can be used to predict the number of crashes based on the collected data through ADAS. So, Avg Yearly Transit Crash is renamed as total predicted transit crashes (Total Crash) in formula (8-3):

$$\text{Total Crash}_i = \text{CF}_i \times \frac{(\text{Observed Conflicts})_i}{\text{ADAS VRM}} \times \text{ City Transit VRM} \quad (8\text{-}3)$$

Total $\text{Crash}_i$ = Predicted crash using Conflict $i$

After finding predictions by using various number of conflicts ($i$) an average of all predictions is considered as predicted number of crashes ($C$). The system could be in stealth mode or active mode while collecting data. If an organization decides to use the ADAS system in both modes for collecting data, the tool accepts both collected data. The tool computes the predicted number of crashes using stealth mode data (C_S) and active mode data (C_A). The tool uses VRMs of the two computation to find a weighted average of both.

$$Cr = \frac{C_\text{S} \times \text{VRM}_\text{S} + C_\text{A} \times \text{VRM}_\text{A}}{\text{VRM}_\text{S} + \text{VRM}_\text{A}} \quad (8\text{-}4)$$

*Cr* = Final predicted number of crashes for the city transit network

S = Stealth mode
A = Active mode
$C_S$ = Predicted number of crashes using the system in **Stealth** mode
$C_A$ = Predicted number of crashes using the system in **Active** mode
VRM = Vehicle Revenue Miles

### 8.2.3 Expected Number of Crashes

The predicted number of crashes (*Cr*) in the tool was calculated. There is also a historical crash input from the user (HC). These two measures should be combined for further calculations. There is a suggested value that says if 12 months of surrogate data (Mobileye Shield+) were collected, the weight between historical and predicted crashes is 50% each. However, the user has the option to choose the weight.

### 8.2.4 Safety Improvements

By considering a linear relationship between the conflicts and crashes, it is possible to use the reductions in the conflicts for the expected reduction in the crashes. The reduction in the conflicts, including all data, is 0.66 (crash modification factor, CMF). The user can enter a desired quantity. By multiplying the expected number of crashes to the suggested or introduced CMF and reducing it from the expected crashes, the reduction in the crashes is found.

## 8.3 Economic Justification

This section explains the process of finding the system costs and benefits, along with the tool outputs. The user can use this tool to understand the economic justification of the Mobileye Shield+ system.

### 8.3.1 Dollar Value of Crashes

Dollar value of crashes in this tool is considered $121,332 for crashes on urban undivided roadways, from FDOT Design Manual as shown in Table 3. Urban undivided roadway was chosen as most of the bus routes in the City of Gainesville are on this road facility type. However, the user can select a value in the tool.

**Table 8-3. Crash cost from FDOT Design Manual**

**Table 122.6.1 FDOT Average Crash Costs by Facility Type**

| Type Facility | Divided Roadway | | | Undivided Roadway | | |
|---|---|---|---|---|---|---|
| | Urban | Suburban | Rural | Urban | Suburban | Rural |
| 2-3 Lanes | $106,967 | $186,651 | $347,278 | $121,332 | $246,741 | $506,164 |
| 4-5 Lanes | $116,176 | $213,668 | $461,464 | $110,657 | $183,491 | n/a |
| 6+ Lanes | $116,034 | $154,430 | $431,516 | $31,282 | n/a | n/a |
| Interstate | $145,263 | n/a | $331,210 | n/a | n/a | n/a |
| Turnpike | $141,607 | n/a | $277,755 | n/a | n/a | n/a |

Notes:

(1) Average Cost/Crash: **$151,677**

(2) The above values were derived from 2011 through 2015 traffic crash and injury severity data for crashes on state roads in Florida using the formulation described in *FHWA Technical Advisory "Motor Vehicle Accident Costs", T 7570.2, dated October 31, 1994* and from a memorandum from USDOT, *Revised Departmental Guidance: Treatment of Economic Value of a Statistical Life (VSL) in the U.S. Department of Transportation Analyses*, dated August 8, 2016 updating the value of life saved from $9.4 million to $9.6 million.

(3) Link to ***Revised Departmental Guidance 2013***

### 8.3.2 Mobileye Shield+ Cost

The system includes two type of investments: installation cost and yearly cost. The one-time installation cost was considered \$8,900, and the yearly cost was \$240 based on the procurement cost for this project.

### 8.3.3 Equivalent Annual Cost

For the benefit-cost analysis, all the benefits and investments need to be consistent in present value or future value. This study converts all the present investments to future value by considering a discount rate of 0.07. The formula for the equivalent annual cost (EAC) is as follows:

$$\mathrm{EAC} = \frac{\text{Asset Price } \times \text{Discount Rate}}{1-(1+\text{Discount Rate})^{n}} \tag{8-5}$$

where asset price is the present value of the investments and n is the future year. The tool considers the life cycle of the Mobileye Shield+ up to 15 years and computes the yearly benefits and costs of the system up to 15 years.

### 8.3.4 Benefit of the System

The yearly benefit of the system is found through multiplying the monetary value of crashes by the yearly expected reduction in crashes using the ADAS system. In the Safety Improvements section, the expected reduction in the crashes through using CMFs was explained. This is considered a lower bound for the benefits of the system. In an ideal world, we can consider that there will be no crashes by using the system. This is considered as the upper bound of the benefits.

It is noteworthy that the expected reduction in the crashes was calculated by considering that the entire transit network uses ADAS technology. However, at the end, the benefits were divided by the total number of buses in transit network.

Table 4, below, provides the output for the Gainesville RTS deployment. As can be seen, considering the lowest lifecycle of the ADAS equipment (5 years), the BC ratio was 1.51 for LB and 4.41 for UB. For a maximum life cycle of 15 years, the BC ratio was 2.98 for LB and 8.73 for UB which signifies a benefit in terms of rate of return for the ADAS investment.

**Table 8-4. ADAS Tool output for Gainesville RTS**

| Life Cycle | LB Vehicle Yearly Benefit | LB Present Value of Benefits | Annuity Factor | Present Value of Cost | LB Net Benefit | LB BC Ratio | UB Vehicle Yearly Benefit | UB Present Value of Benefits | UB Net Benefit | UB BC Ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | $3,631 | $14,886 | 4.100 | $9,884 | **$5,003** | **1.51** | $10,625 | $43,566 | **$33,682** | **4.41** |
| 6 | $3,631 | $17,306 | 4.767 | $10,043 | **$7,262** | **1.72** | $10,625 | $50,646 | **$40,603** | **5.04** |
| 7 | $3,631 | $19,567 | 5.389 | $10,193 | **$9,374** | **1.92** | $10,625 | $57,263 | **$47,070** | **5.62** |
| 8 | $3,631 | $21,680 | 5.971 | $10,332 | **$11,347** | **2.10** | $10,625 | $63,447 | **$53,115** | **6.14** |
| 9 | $3,631 | $23,655 | 6.515 | $10,463 | **$13,192** | **2.26** | $10,625 | $69,227 | **$58,764** | **6.62** |
| 10 | $3,631 | $25,500 | 7.024 | $10,585 | **$14,916** | **2.41** | $10,625 | $74,628 | **$64,043** | **7.05** |
| 11 | $3,631 | $27,225 | 7.499 | $10,699 | **$16,526** | **2.54** | $10,625 | $79,676 | **$68,977** | **7.45** |
| 12 | $3,631 | $28,837 | 7.943 | $10,805 | **$18,032** | **2.67** | $10,625 | $84,394 | **$73,588** | **7.81** |
| 13 | $3,631 | $30,344 | 8.358 | $10,905 | **$19,439** | **2.78** | $10,625 | $88,803 | **$77,898** | **8.14** |
| 14 | $3,631 | $31,752 | 8.745 | $10,998 | **$20,754** | **2.89** | $10,625 | $92,924 | **$81,926** | **8.45** |
| 15 | $3,631 | $33,068 | 9.108 | $11,085 | **$21,983** | **2.98** | $10,625 | $96,775 | **$85,690** | **8.73** |

# Chapter 9 – Conclusions

RTS experienced a higher transit crash rate (per VRMs) in 2017 and 2018 on average between the years 2015 and 2019. Gainesville experienced a 39.5% higher transit crash rate and an 11.6% higher fatal and injury rate in comparison to the National Transit Database. This study provided an opportunity for the city of Gainesville and RTS to experience the ADAS system. In addition, it allowed the study team to collect longitudinal data to understand the potential safety implications over an extended period.

The Mobileye Shield+ system was installed on 10 RTS buses; however, three units malfunctioned shortly after the install date. A before-after analysis was conducted, and the data were collected for over a year. The raw data were collected from the Ituran Web interface, which is an extensive visualization and data access tool; critical training on several reporting features was provided by the vendor. For individual route-based analysis, it was essential that the data were retrieved based on routes; however, upon detailed analysis and follow-up discussion with the vendor, it was found that the interface failed to associate individual routes with unique conflicts because no agency had requested it previously. As such, manual data processing was adopted for route-based analysis. The preliminary results revealed that the vehicles changed routes during the study period. As a result, a manual methodology was developed to correlate each vehicle alert to a route. The collected data were scrubbed and fused to make one inclusive database including the alerts and route numbers.

Two before-after analyses were conducted in this study: aggregate analysis and route-based analysis. The aggregate analysis compared the entire collected data between stealth and the open mode regardless of the routes of buses. The route-based analysis compares the stealth and open mode on each route.

The aggregate analysis compared all collected data between stealth and open modes regardless of bus route. The route-based analysis compared the stealth and open modes on each route. When the stealth (Jan. and Feb. 2019) mode was compared with only Jan. and Feb. 2020 (same time period, STP), the conflict modification factor (CoMF), including all data using the aggregate data, was 75.60%, and for the STP, it was 65.83% (equivalent to 34.17% reduction in the conflicts). For the route-based analysis, there was not enough data to do STP analysis. The CoMF from this analysis was 80.05%, and by dropping an outlier, it decreased to 73.59% (equivalent to 26.41% reduction in the conflicts). This translates to a reduction of 26% to 34% in the conflicts. In the aggregate data analysis (STP), the three largest reductions were for HWW, AggBrk, and PCW: 48.30%, 47.60%, 33.40% reduction, respectively. These data indicate that with the introduction of ADAS, the number of conflicts were reduced.

The hotspot analysis focused on finding the locations with higher risk factors. With the Ituran interface, the reports generated do not eliminate redundant conflicts nor does the system normalize the data sets. As such, most of the locations identified were locations with high pedestrian demand. A weighted safety risk methodology was implemented to find the locations with higher risk factors. The main risk factors that were found included intersection vicinity, roundabout, parking, and high-density residential areas.

From the bus driver focus groups, it was concluded that most drivers (about 75%) found the system useful, especially on the UF campus. Despite the overall usefulness, many drivers reported alarms with no reason (false positives), which was annoying to the drivers and reduced their trust in the system. Some drivers mentioned that the system does not show alarms in dark conditions. This system is visual-based and relies on installed cameras. As such, the system alerts are not applicable in dark conditions. This needs to be emphasized when drivers are initially trained because none of the drivers recalled having been informed of this limitation of the system.

Most drivers participating in the focus groups mentioned a preference for having this technology on their bus. Based on the focus group results, the system needs improvements to gain higher trust from the drivers. Among the 16 drivers who were asked about the automated braking system, only one wanted such technology.

For any emerging technology, financial justification and cost-effectiveness are essential criteria for decision-makers. This study included a benefit-cost analysis tool for assessing the economic justification of using this technology. This tool could be used by users to figure out the benefits of using such technology in various routes. This tool was designed to get the collected ADAS data and combine them with the historical crashes to develop the expected number of transit crashes. The surrogate safety data were collected in Gainesville, FL, only. This decreases the transferability of the tool where traffic characteristics are different and the Gainesville-based surrogate safety assessment parameters might not apply. To resolve this, agencies could collect data in their region and update the models. Also, the data of 28 transit agencies are embedded in the tool and the user can choose among them. The tool can be used to perform a benefit-cost analysis of Mobileye Shield+ for these transit agencies. These nine agencies had a positive net benefit: Orlando, Plantation, West Palm Beach, St. Petersburg, Tampa, Miami, Jacksonville, Gainesville, and Fort Myers. One can observe that these nine agencies have experienced higher crash frequency and have higher average VRM. The model indicated that agencies with higher crash history, relatively larger transit fleet, and high VRM could lower the potential conflicts with the installation of ADAS units.

**Table 9-1. The benefit of ADAS system in various Florida cities**

| Community | Lower Bound of Net Benefits | Lower Bound Benefit-to-Cost Ratio | Upper Bound of Net Benefits | Upper Bound of Benefit-to-Cost Ratio |
|---|---|---|---|---|
| Orlando | $74,996 | 8.59 | $238,521 | 25.13 |
| Plantation | $69,677 | 8.05 | $222,953 | 23.56 |
| West Palm Beach | $48,630 | 5.92 | $161,360 | 17.33 |
| St. Petersburg | $44,930 | 5.55 | $150,530 | 16.23 |
| Tampa | $41,923 | 5.24 | $141,731 | 15.34 |
| Miami | $33,828 | 4.42 | $118,041 | 12.94 |
| Jacksonville | $26,427 | 3.67 | $96,382 | 10.75 |
| Gainesville | $4,918 | 1.50 | $33,435 | 4.38 |
| Fort Myers | $2,606 | 1.26 | $26,666 | 3.70 |
| Bradenton | ($401) | 0.96 | $17,867 | 2.81 |
| South Daytona | ($2,020) | 0.80 | $13,129 | 2.33 |
| Port Richey | ($2,483) | 0.75 | $11,776 | 2.19 |

**Table 9-1, continued**

| Community | Lower Bound of Net Benefits | Lower Bound Benefit-to-Cost Ratio | Upper Bound of Net Benefits | Upper Bound of Benefit-to-Cost Ratio |
|---|---|---|---|---|
| Fort Pierce | ($5,027) | 0.49 | $4,330 | 1.44 |
| Pensacola | ($5,027) | 0.49 | $4,330 | 1.44 |
| Lakeland | ($5,258) | 0.47 | $3,653 | 1.37 |
| Sarasota | ($5,721) | 0.42 | $2,300 | 1.23 |
| Cocoa | ($6,183) | 0.37 | $946 | 1.10 |
| Punta Gorda | ($7,571) | 0.23 | –$3,115 | 0.68 |
| Tallahassee | ($7,802) | 0.21 | –$3,792 | 0.62 |
| Fort Lauderdale | ($8,496) | 0.14 | –$5,822 | 0.41 |
| Naples | ($8,958) | 0.09 | –$7,176 | 0.27 |
| Fort Walton Beach | ($9,421) | 0.05 | –$8,530 | 0.14 |
| Stuart | ($9,421) | 0.05 | –$8,530 | 0.14 |
| Tavares | ($9,421) | 0.05 | –$8,530 | 0.14 |
| Pompano Beach | ($9,652) | 0.02 | –$9,207 | 0.07 |
| Vero Beach | ($9,652) | 0.02 | –$9,207 | 0.07 |
| Bunnell | ($9,884) | 0.00 | –$9,884 | 0.00 |
| Ocala | ($9,884) | 0.00 | –$9,884 | 0.00 |

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# Appendix A – RTS Bus Route Maps

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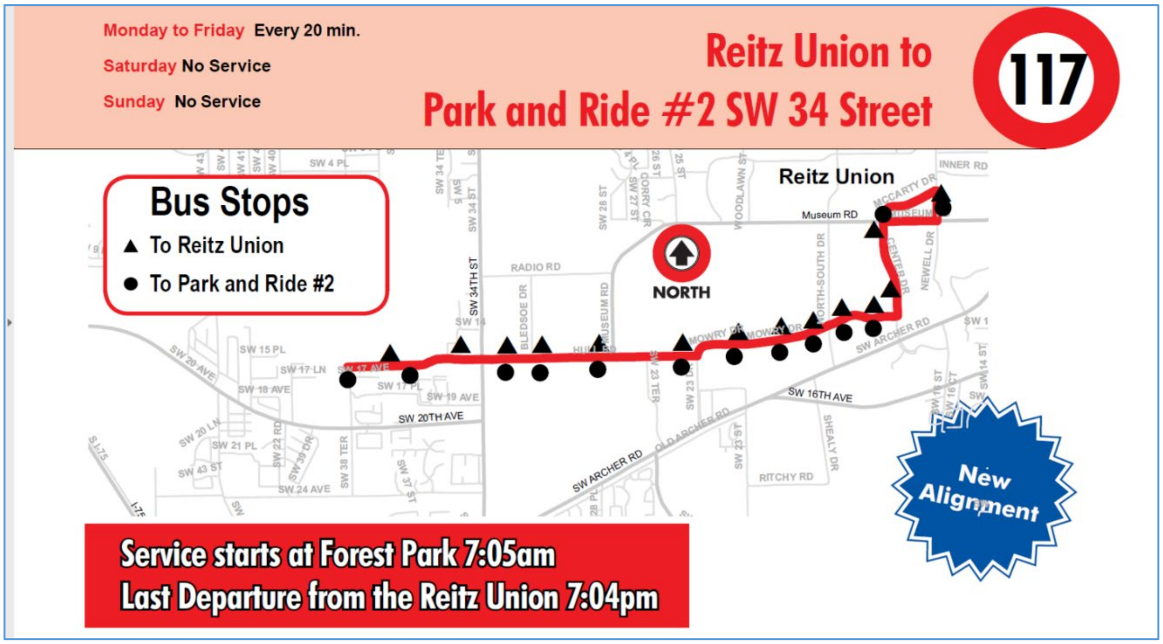



Figure A-2 – Campus route 117 information

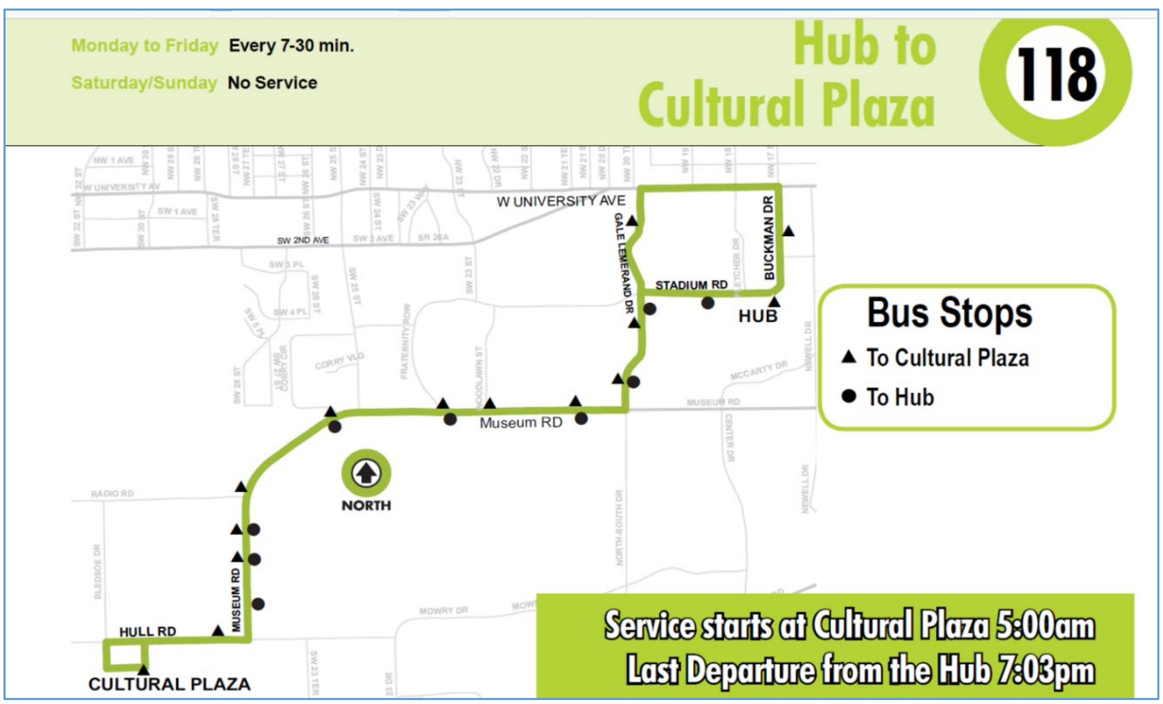



Figure A-1 – Campus route 118 information

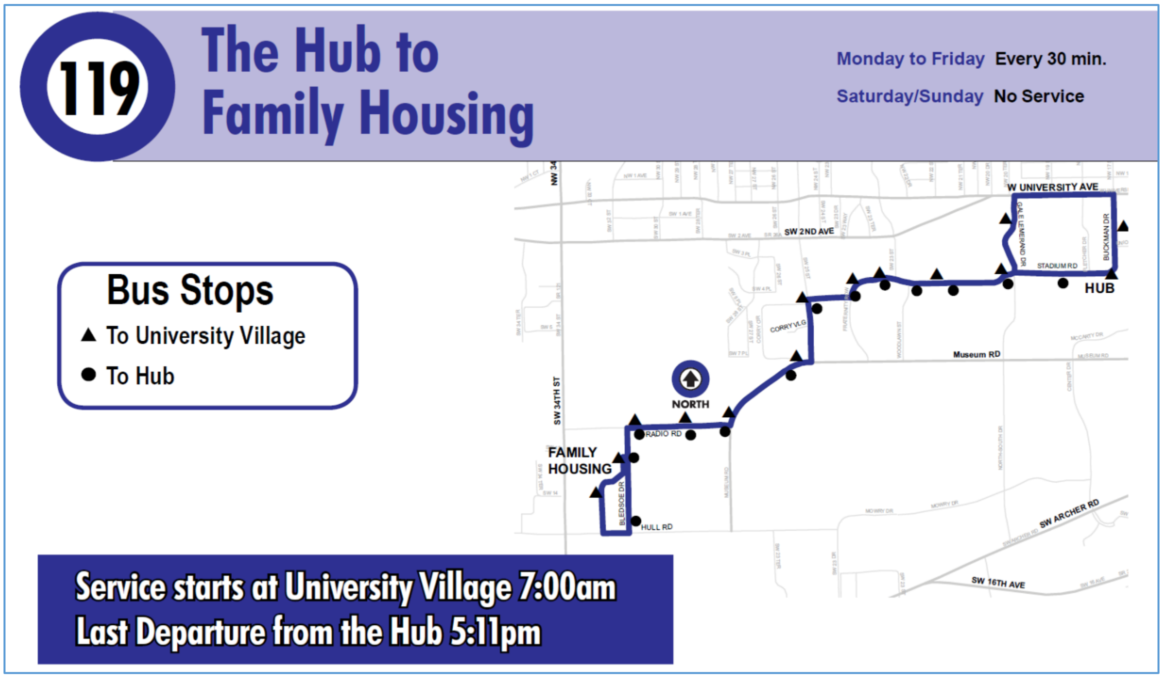



Figure A-3 – Campus route 119 information

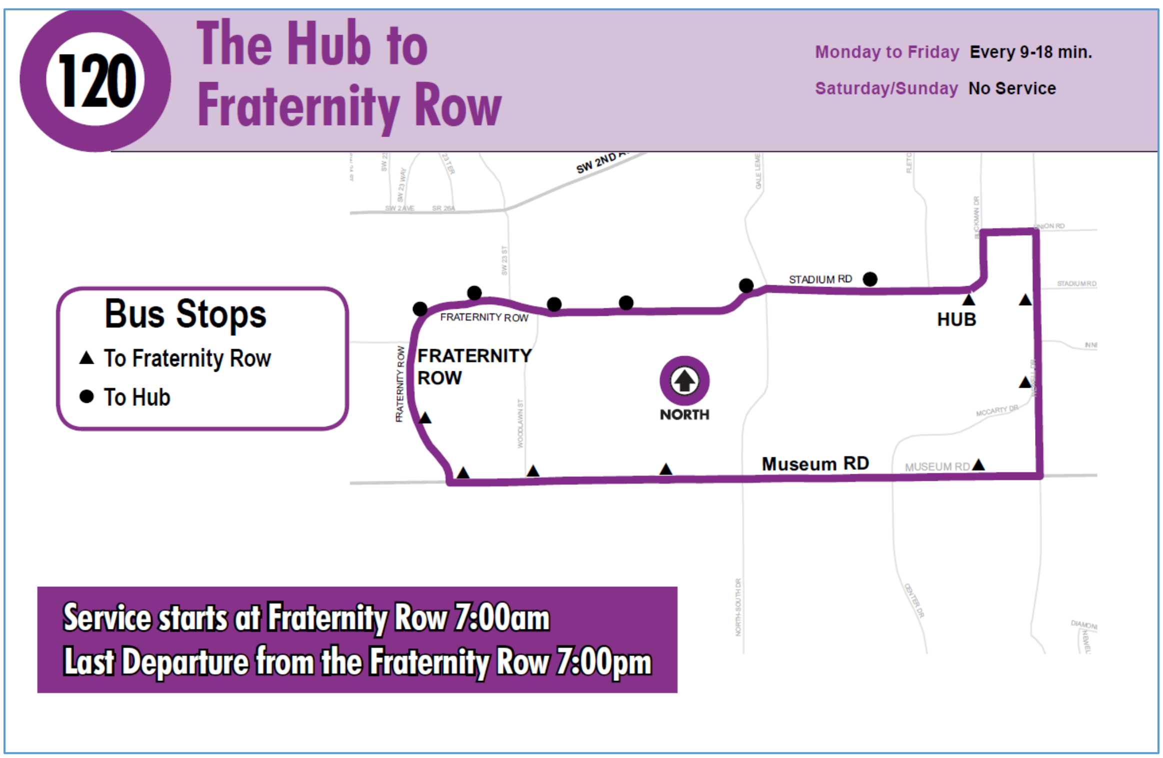



Figure A-4 – Campus route 120 information

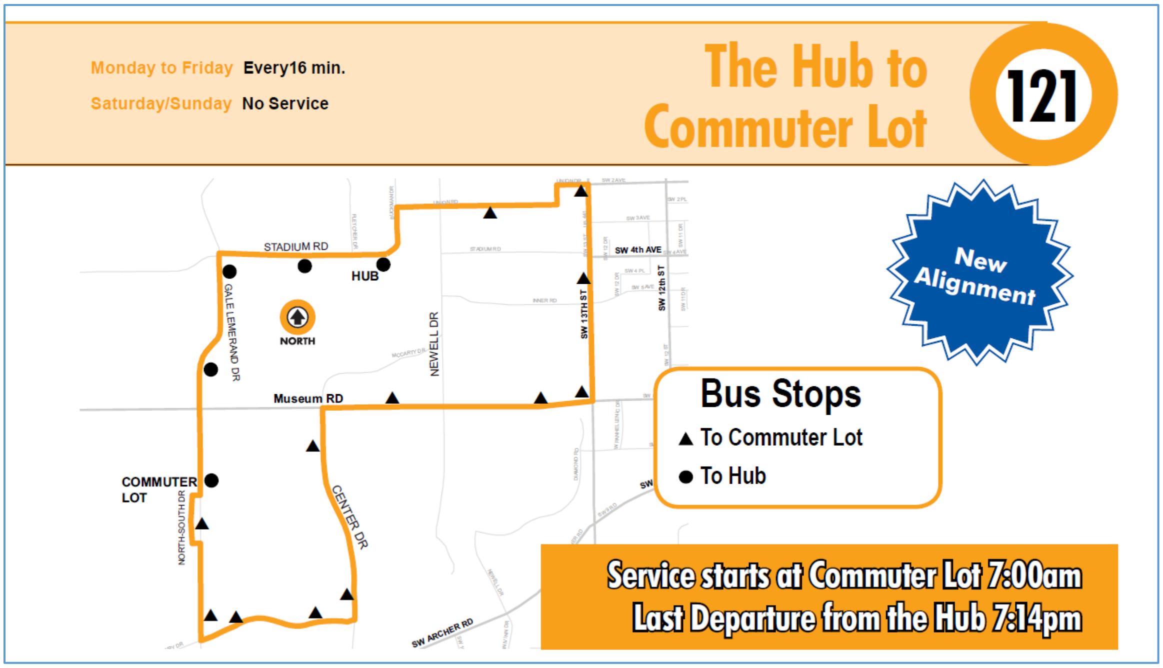



**Figure A-5 – Campus route 121 information**

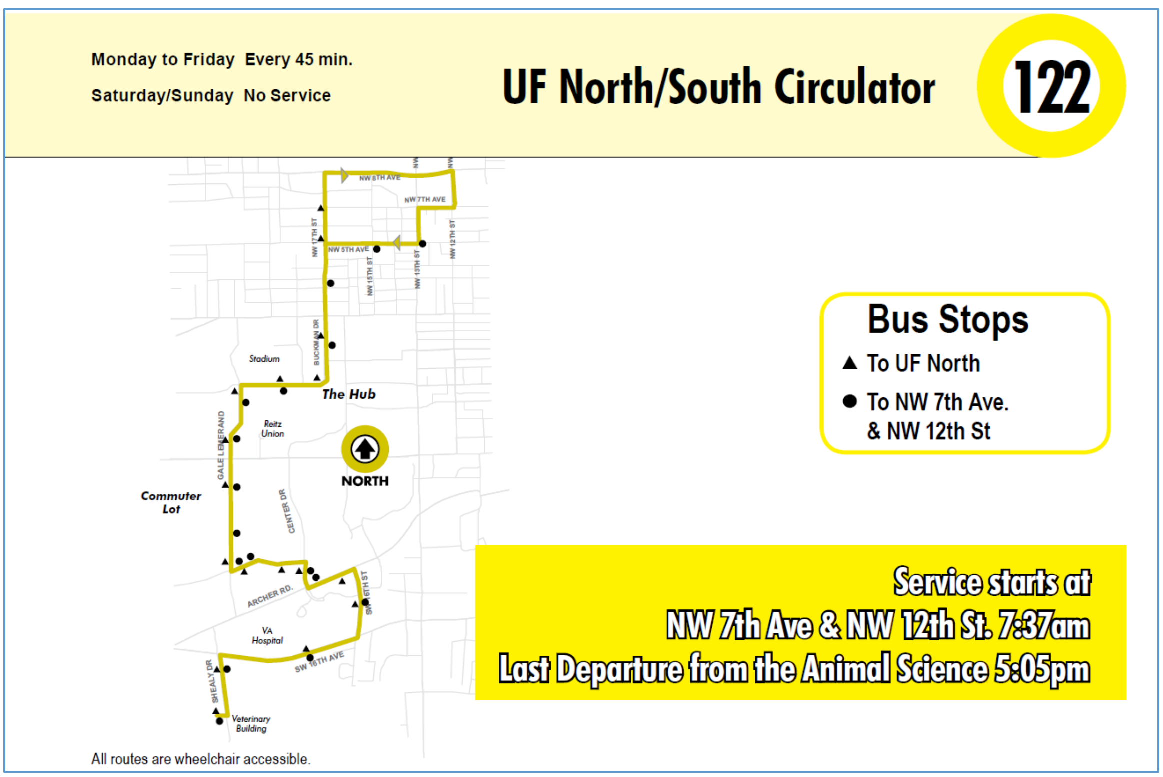



**Figure A-6 – Campus route 122 information**

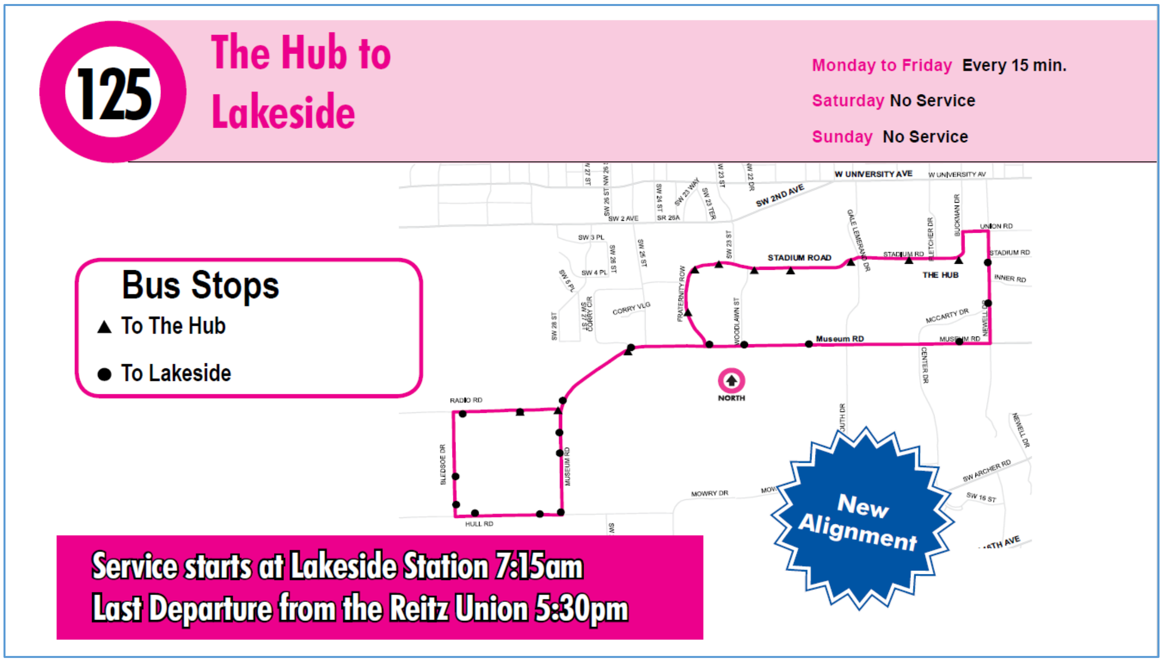



Figure A-7 – Campus route 125 information

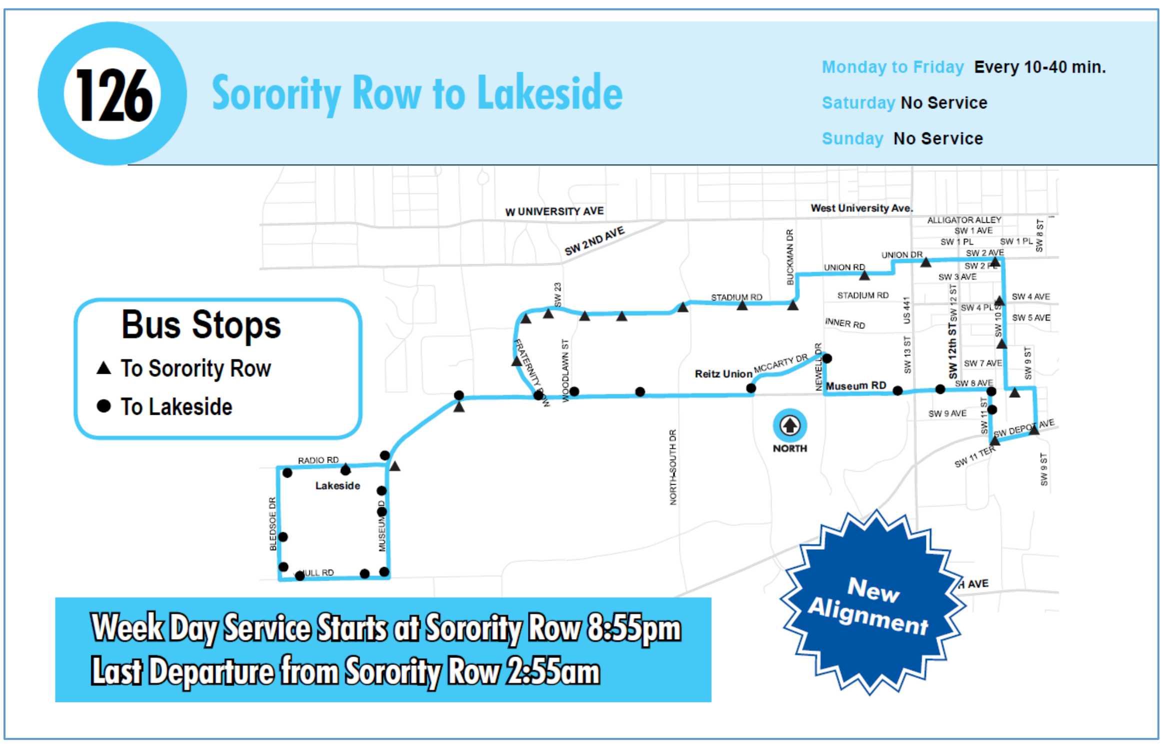



Figure A-8 – Campus route 126 information

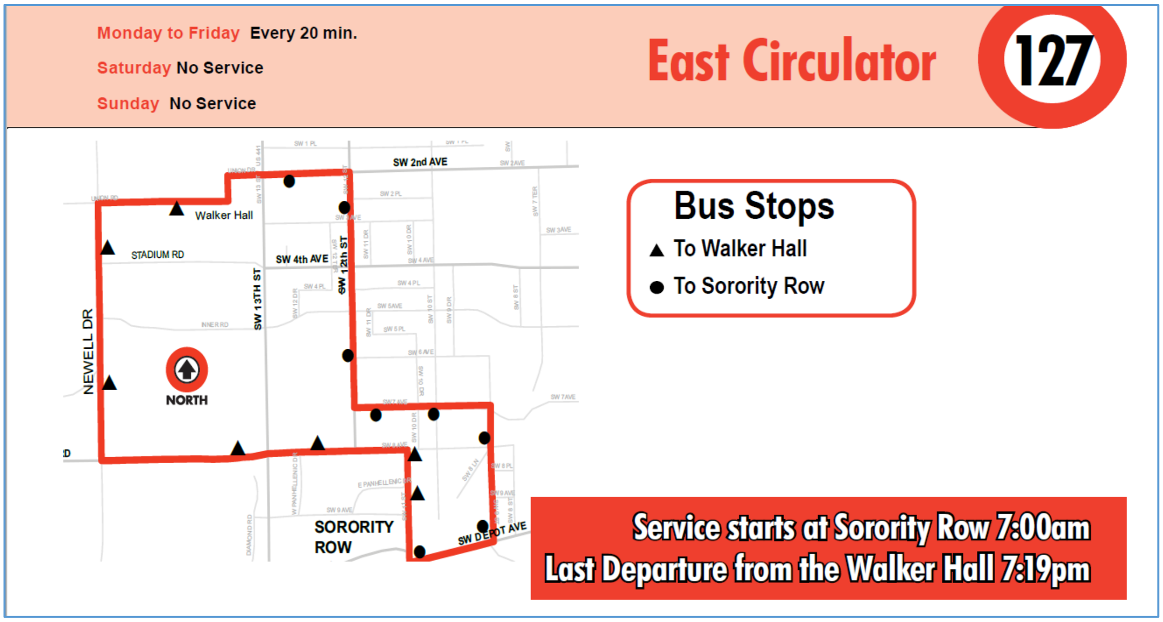



**Figure A-9 – Campus route 127 information**

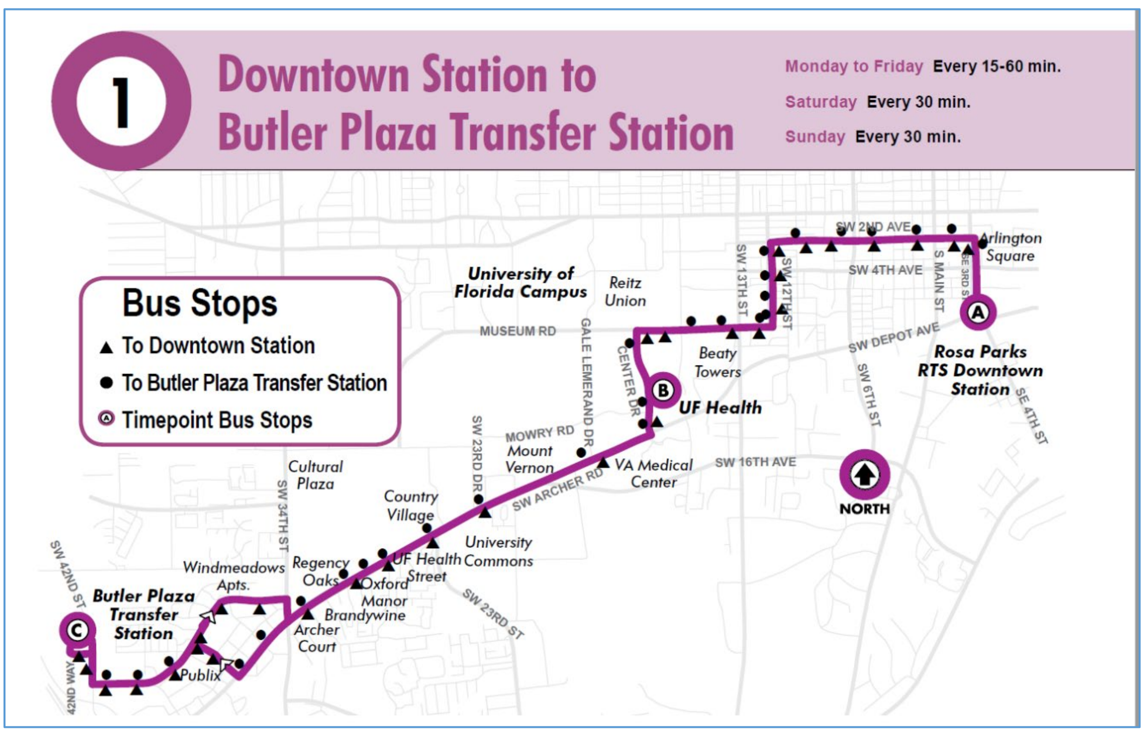



**Figure A-10 – City route 1 information**

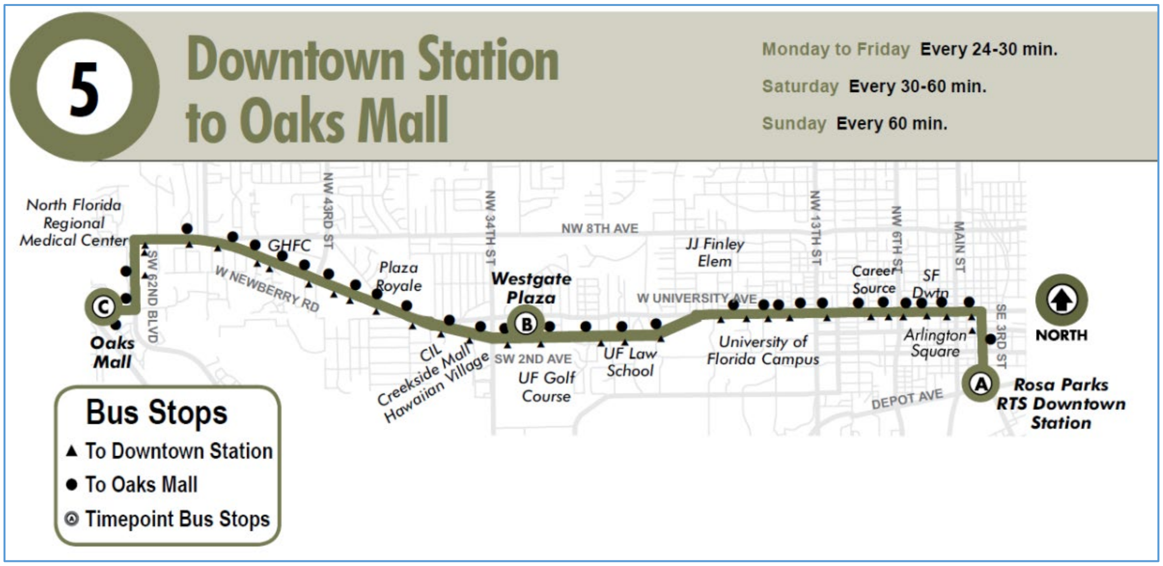



**Figure A-11 – City route 5 information**

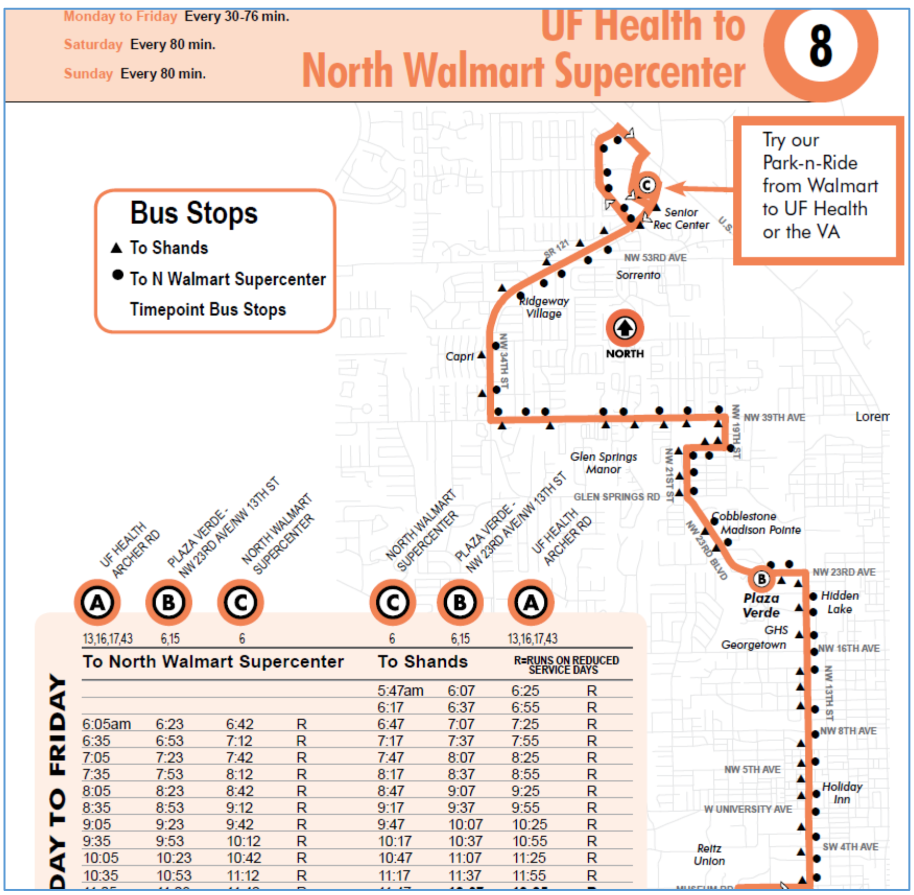



**Figure A-12 – City route 8 information**


**Figure A-13 – City route 9 information**


**Figure A-14 – City route 10 information**

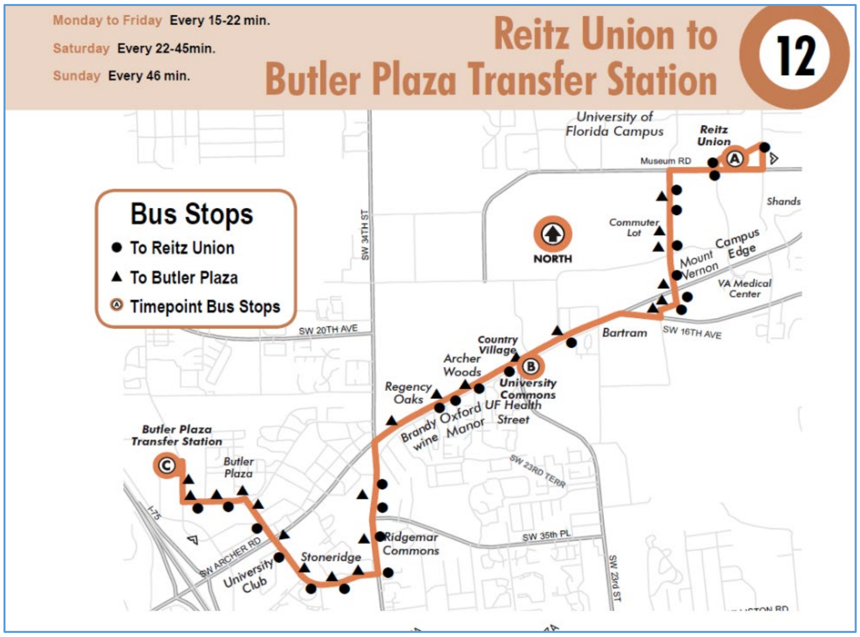



**Figure A-15 – City route 12 information**

## 13 Beaty Towers to Cottage Grove Apartments

Monday to Friday Every 15-30 min.
Saturday Every 60 min.
Sunday Every 60 min.

**MONDAY TO FRIDAY**

| To US 441 South: (A) REITZ UNION AFTER 8:00PM (1,8,9,12,20, 35,38,43) | (B) BEATY TOWERS (1,8,16,17,43) | (C) US 441 SOUTH | | To Beaty Towers or Reitz Union: (C) US 441 SOUTH | (B) BEATY TOWERS (1,8,16,17,43) | (A) REITZ UNION AFTER 8:00PM (1,8,9,12,20, 35,38,43) | R=RUNS ON REDUCED SERVICE DAYS |
|---|---|---|---|---|---|---|---|
| | | | | 6:36am | 6:45 | | R |
| | | | | 6:51 | 7:00 | | |
| | 6:45am | 6:59 | R | 7:06 | 7:15 | | R |
| | 7:00 | 7:14 | | 7:21 | 7:30 | | |
| | 7:15 | 7:29 | R | 7:36 | 7:45 | | R |
| | 7:30 | 7:44 | | 7:51 | 8:00 | | |
| | 7:45 | 7:59 | R | 8:06 | 8:15 | | R |
| | 8:00 | 8:14 | | 8:21 | 8:30 | | |
| | 8:15 | 8:29 | R | 8:36 | 8:45 | | R |
| | 8:30 | 8:44 | | 8:51 | 9:00 | | |
| | 8:45 | 8:59 | R | 9:06 | 9:15 | | R |
| | 9:00 | 9:14 | | 9:21 | 9:30 | | |
| | 9:15 | 9:29 | R | 9:36 | 9:45 | | R |
| | 9:30 | 9:44 | | 9:51 | 10:00 | | |
| | 9:45 | 9:59 | R | 10:06 | 10:15 | | R |
| | 10:00 | 10:14 | | 10:21 | 10:30 | | |
| | 10:15 | 10:29 | R | 10:36 | 10:45 | | R |
| | 10:30 | 10:44 | | 10:51 | 11:00 | | |
| | 10:45 | 10:59 | R | 11:06 | 11:15 | | R |
| | 11:00 | 11:14 | | 11:21 | 11:30 | | |
| | 11:15 | 11:29 | R | 11:36 | 11:45 | | R |
| | 11:30 | 11:44 | | 11:51 | 12:00pm | | |
| | 11:45 | 11:59 | R | 12:06 | 12:15 | | R |
| | 12:00pm | 12:14 | | 12:21 | 12:30 | | |
| | 12:15 | 12:29 | R | 12:36 | 12:45 | | R |
| | 12:30 | 12:44 | | 12:51 | 1:00 | | |
| | 12:45 | 12:59 | R | 1:06 | 1:15 | | R |
| | 1:00 | 1:14 | | 1:21 | 1:30 | | |
| | 1:15 | 1:29 | R | 1:36 | 1:45 | | R |
| | 1:30 | 1:44 | | 1:51 | 2:00 | | |
| | 1:45 | 1:59 | R | 2:06 | 2:15 | | R |
| | 2:00 | 2:14 | | 2:21 | 2:30 | | |
| | 2:15 | 2:29 | R | 2:36 | 2:45 | | R |
| | 2:30 | 2:44 | | 2:51 | 3:00 | | |
| | 2:45 | 2:59 | R | 3:06 | 3:15 | | R |
| | 3:00 | 3:14 | | 3:21 | 3:30 | | |
| | 3:15 | 3:29 | R | 3:36 | 3:45 | | R |
| | 3:30 | 3:44 | | 3:51 | 4:00 | | |
| | 3:45 | 3:59 | R | 4:06 | 4:15 | | R |
| | 4:00 | 4:14 | | 4:21 | 4:30 | | |
| | 4:15 | 4:29 | R | 4:36 | 4:45 | | R |
| | 4:30 | 4:44 | | 4:51 | 5:00 | | |
| | 4:45 | 4:59 | R | 5:06 | 5:15 | | R |
| | 5:00 | 5:14 | | 5:21 | 5:30 | | |
| | 5:15 | 5:29 | R | 5:36 | 5:45 | | R |
| | 5:30 | 5:44 | | 5:51 | 6:00 | | |
| | 5:45 | 5:59 | R | 6:06 | 6:15 | | R |
| | 6:00 | 6:14 | | | | | |
| | 6:15 | 6:29 | R | 6:36 | 6:45 | | R |
| | 6:45 | 6:59 | R | 7:06 | 7:15 | | R |
| | 7:15 | 7:29 | R | 7:36 | 7:45 | | R |
| | 7:45 | 7:59 | R | 8:06 | | 8:17 | R |
| 8:30 | | 8:41 | R | 8:41 | | 8:52 | R |
| 9:00 | | 9:11 | R | 9:11 | | 9:22 | R |
| 9:30 | | 9:41 | R | 9:41 | | 9:52 | R |
| 10:00 | | 10:11 | R | 10:11 | | 10:22 | R |
| 10:30 | | 10:41 | R | 10:41 | | 10:52 | R |
| 11:00 | | 11:11 | R | | | | |


42

**Figure A-16 – City route 13 information**

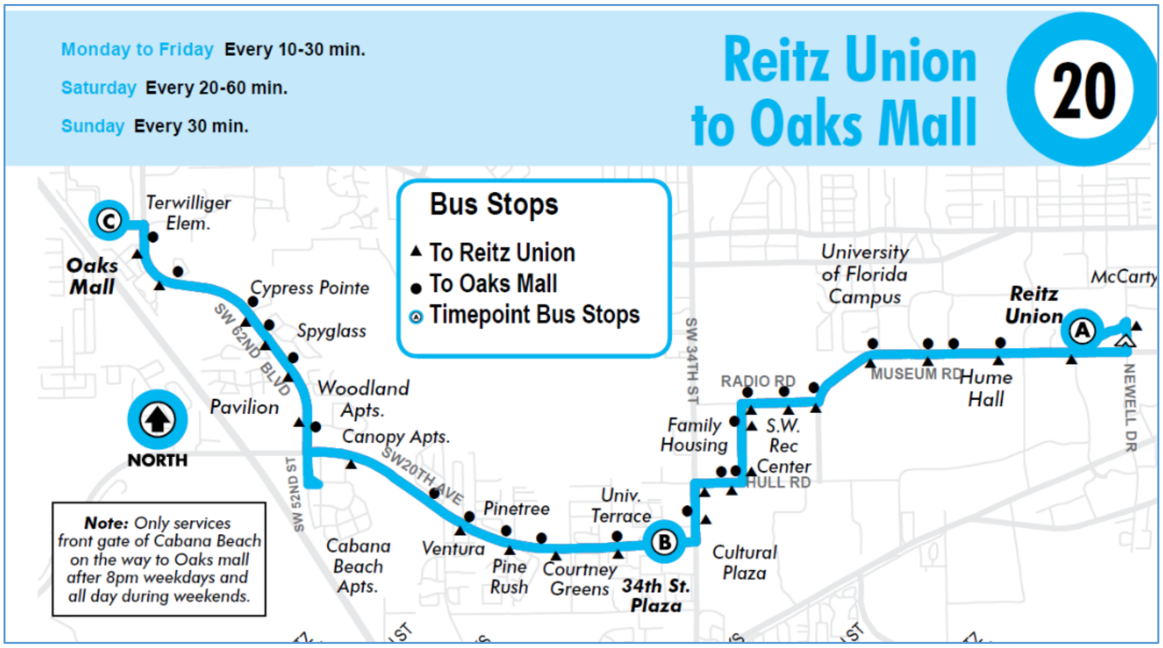
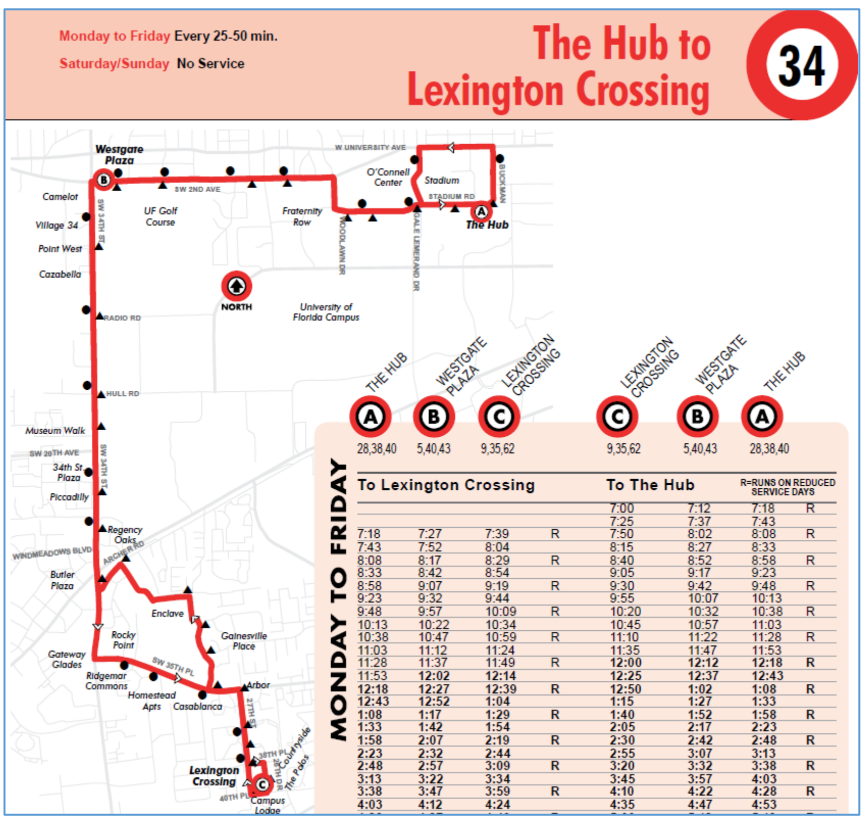



**Figure A-17 – City route 20 information**




MONDAY TO FRIDAY

| To Lexington Crossing | | | | To The Hub | | | R=RUNS ON REDUCED SERVICE DAYS |
|---|---|---|---|---|---|---|---|
| Ⓐ THE HUB 28,38,40 | Ⓑ WESTGATE PLAZA 5,40,43 | Ⓒ LEXINGTON CROSSING 9,35,62 | | Ⓒ LEXINGTON CROSSING 9,35,62 | Ⓑ WESTGATE PLAZA 5,40,43 | Ⓐ THE HUB 28,38,40 | |
| | | | | 7:00 | 7:12 | 7:18 | R |
| | | | | 7:25 | 7:37 | 7:43 | |
| 7:18 | 7:27 | 7:39 | R | 7:50 | 8:02 | 8:08 | R |
| 7:43 | 7:52 | 8:04 | | 8:15 | 8:27 | 8:33 | |
| 8:08 | 8:17 | 8:29 | R | 8:40 | 8:52 | 8:58 | R |
| 8:33 | 8:42 | 8:54 | | 9:05 | 9:17 | 9:23 | |
| 8:58 | 9:07 | 9:19 | R | 9:30 | 9:42 | 9:48 | R |
| 9:23 | 9:32 | 9:44 | | 9:55 | 10:07 | 10:13 | |
| 9:48 | 9:57 | 10:09 | R | 10:20 | 10:32 | 10:38 | R |
| 10:13 | 10:22 | 10:34 | | 10:45 | 10:57 | 11:03 | |
| 10:38 | 10:47 | 10:59 | R | 11:10 | 11:22 | 11:28 | R |
| 11:03 | 11:12 | 11:24 | | 11:35 | 11:47 | 11:53 | |
| 11:28 | 11:37 | 11:49 | R | 12:00 | 12:12 | 12:18 | R |
| 11:53 | 12:02 | 12:14 | | 12:25 | 12:37 | 12:43 | |
| 12:18 | 12:27 | 12:39 | R | 12:50 | 1:02 | 1:08 | R |
| 12:43 | 12:52 | 1:04 | | 1:15 | 1:27 | 1:33 | |
| 1:08 | 1:17 | 1:29 | R | 1:40 | 1:52 | 1:58 | R |
| 1:33 | 1:42 | 1:54 | | 2:05 | 2:17 | 2:23 | |
| 1:58 | 2:07 | 2:19 | R | 2:30 | 2:42 | 2:48 | R |
| 2:23 | 2:32 | 2:44 | | 2:55 | 3:07 | 3:13 | |
| 2:48 | 2:57 | 3:09 | R | 3:20 | 3:32 | 3:38 | R |
| 3:13 | 3:22 | 3:34 | | 3:45 | 3:57 | 4:03 | |
| 3:38 | 3:47 | 3:59 | R | 4:10 | 4:22 | 4:28 | R |
| 4:03 | 4:12 | 4:24 | | 4:35 | 4:47 | 4:53 | |

**Figure A-18 – City route 34 information**

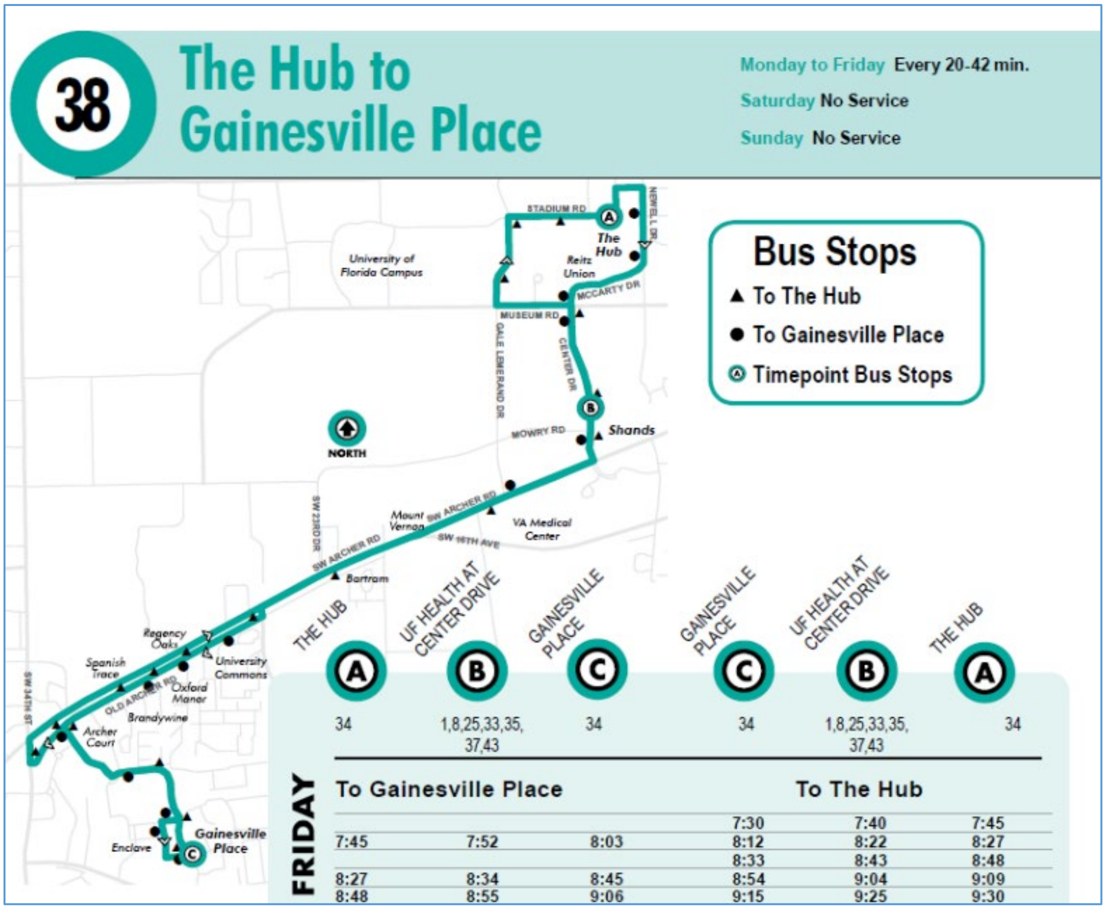



**Figure A-19 – City route 38 information**

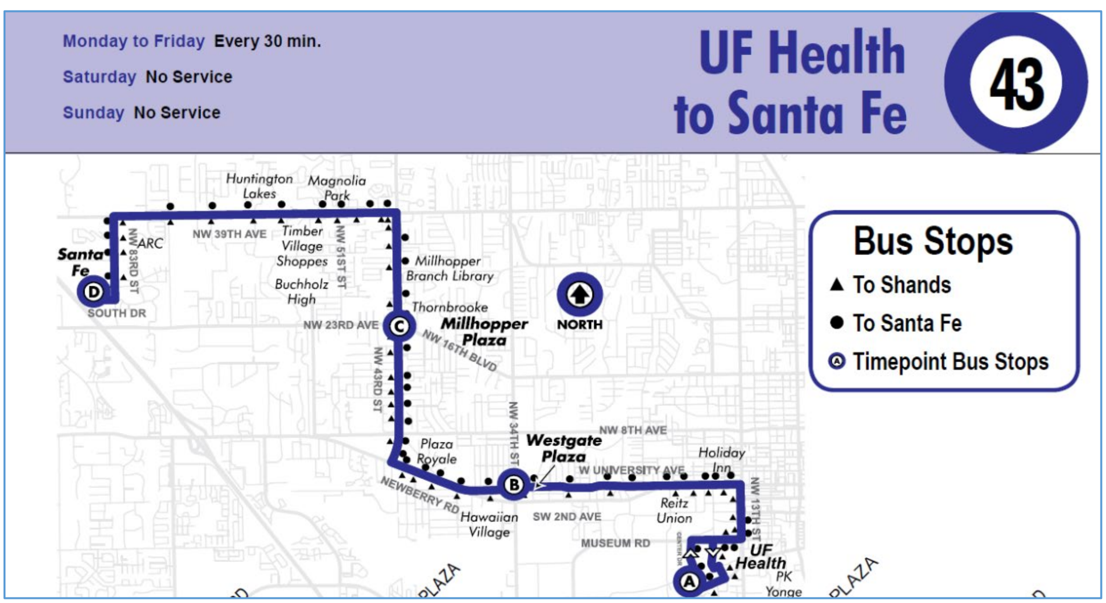



**Figure A-20 – City route 43 information**

# Appendix B – Informed Consent Document

The following is the text of the informed consent that all participants in ADAS focus groups were required to complete, in accordance with University of Florida Internal Review Board procedures.

**Informed Consent**

**Protocol Title**

University of Florida (UF) Testbed Initiative Alternative Transportation Safety Systems

**Please read this consent document carefully before you decide to participate in this study.**

**Purpose of the research study**

The purpose of this study is to examine the usefulness of the Mobileye Shield+ driver assistance system.

**What you will be asked to do in the study**

**Time required**

1 hour

**Risks and Benefits**

We do not anticipate that you will benefit directly by participating in this experiment.

**Compensation**

You will receive a $20 gift card as compensation for participating in this research.

**Confidentiality**

Your identity will be kept confidential to the extent provided by law. Your information will be assigned a code number. The list connecting your name to this number will be kept in a locked file in the principal investigator's office. When the study is completed and the data have been analyzed, the list will be destroyed. Your name will not be used in any report.

**Voluntary participation**

Your participation in this study is completely voluntary. There is no penalty for not participating.

**Right to withdraw from the study**

You have the right to withdraw from the study at any time without consequence.

**Who to contact if you have questions about the study**

Clark Letter, Research Assistant Professor, University of Florida Transportation Institute, 321-298-4360, clarklet@ufl.edu.

Nithin Agarwal, PhD, Safety Engineer, University of Florida Transportation Technology Transfer Center, 352-273-1674, nithin.agarwal@ufl.edu.

**Who to contact about your rights as a research participant in the study**

IRB02 Office

Box 112250

University of Florida

Gainesville, FL 32611-2250

phone 392-0433.

**Agreement**

**I have read the procedure described above. I voluntarily agree to participate in the focus group and I have received a copy of this description.**

Participant: ______________________________________________ Date: __________________

Principal Investigator: _____________________________________ Date: __________________

# Appendix C – Mobileye Shield+ Installation Guide

The following pages display the Mobileye Shield+ Installation Guide. This information is proprietary and is presented with written approval from the vendor to share it with the Florida Department of Transportation. We have advised the vendor that all reports submitted are subject to public record law and they have acknowledged it, as shown in the following email correspondence.

**RE: Installation Guide Usage**

Mike Cacic <mikec@roscovision.com>
Thu 5/2/2019 3:57 PM
**To:** Letter,Clark <clarklet@ufl.edu>
**Cc:** Ross Braddock <rossb@roscovision.com>

Clark,

No issue with providing installation guide to FDOT.

Regards,

Mike Cacic
Program Manager – Collision Avoidance Systems
Rosco Collision Avoidance Inc.
90-21 144th Place
Jamaica, NY 11435-4397 USA
Web: http://rosco-adas.com
Office: 800 227-2095 ext 203
Cell: 631-335-2890
Email: mikec@rosco-adas.com

---

**From:** Letter,Clark [mailto:clarklet@ufl.edu]
**Sent:** Thursday, May 02, 2019 1:46 PM
**To:** Mike Cacic <mikec@roscovision.com>
**Subject:** Installation Guide Usage

Mike,

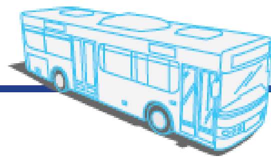
Thanks for sending all the materials for our report. Since the installation guide is marked confidential, would we have permission to publish this in our deliverable report? Please know that all documents submitted to FDOT will be public record, and you would be providing unconditional approval for us to send it. Once it is sent, we cannot do anything about it and may be liable. Let me know your thoughts.

Thanks,
Clark

**Clark Letter, Ph.D.** | Research Assistant Professor
t: (321) 298-4360
e: clarklet@ufl.edu
w: www.transportation.institute.ufl.edu/

UF | Transportation Institute
UNIVERSITY of FLORIDA

MOBILEYE® SHIELD+™ COLLISION AVOIDANCE SYSTEM



# TRANSIT BUS

## INSTALLATION PROCEDURE


Always check the vehicle for any damage before starting the installation.
If damage occurs during the installation, DO NOT continue until the fleet manager is notified.

ROSCO COLLISION AVOIDANCE
T: 718.408.7388
WWW.ROSCO-ADAS.COM

ROSCO COLLISION AVOIDANCE
OFFICIAL MOBILEYE PARTNER

PROPRIETARY & CONFIDENTIAL
VERSION 1.11.1

## Table of Contents

## 1 - Introduction

**This document details the installation of the Mobileye Shield+ System. ROSCO's project management personnel will provide the installer with the bus numbers and their locations prior to installation.**

During the installation, the installer will be responsible for completing the following forms and submitting them to the ROSCO project manager.

- Pre-and Post-Installation Checklist
- Exceptions
- Acceptance Test Procedure Signoff Sheet

***Note:*** *These forms must be submitted before an installation will be considered complete.*

### General Workmanship Standards

Installers shall follow good workmanship techniques consistent with accepted industry standard practices. Installers will be responsible for any damage that results from poor workmanship, failure to follow accepted practices or specific instructions contained in this manual.

### 2.1 - Safety

Always wear safety equipment when working in and around the bus. Safety vests and eye protection are mandatory. Use of ladders requires the permission and supervision of the Fleet Manager.

### 2.2 - Drilling and Cutting

When drilling or cutting make certain that you do NOT damage anything behind the panel you are drilling and/or cutting into. Take adequate precautions such as removing the piece or protecting any underlying structures, cables, hoses, engine air intake etc. by using a backing plate, blanket or a drill stop to prevent excessive drill penetration. After any cutting or drilling operation thoroughly remove all sharp edges and burrs on both sides. Remove any debris caused by cutting or drilling.

***Note:*** *Any Drilling or Cutting requires Safety Glasses*

### 2.3 Mounting Components and Locations

**Use Nylock Nuts, Lock Washers or threaded inserts on all mounting hardware.**

If the installer finds that the specified hardware is incorrect or inadequate, that the specified mounting location is not available or some other issue the installer shall notify ROSCO in writing of the problem as soon as possible. ROSCO will provide the installer with written instructions on how to proceed. Any deviations from the procedures or equipment contained in this installation manual must be approved by ROSCO.

### 2.4 Harness Installation

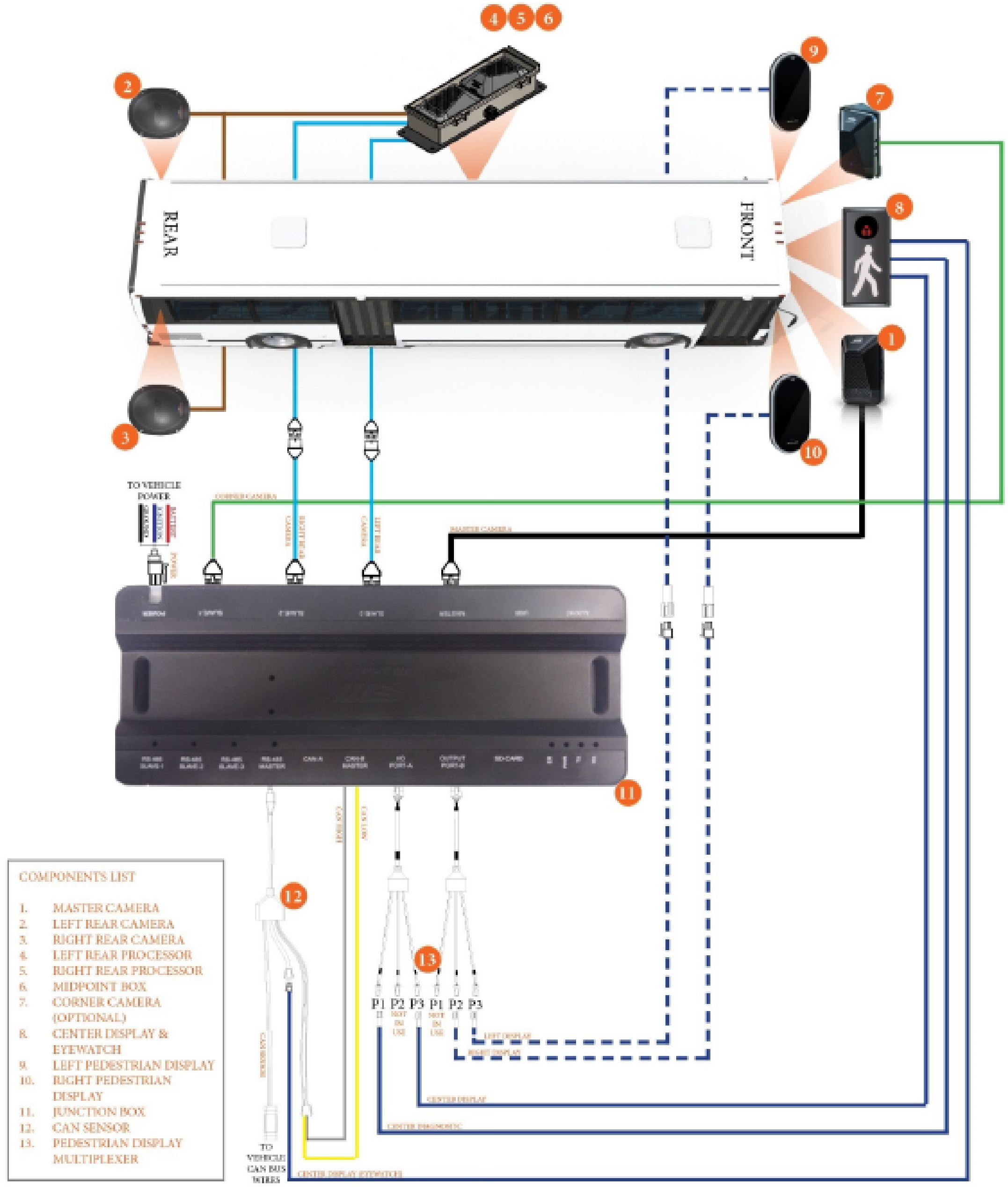
When installing the harness, care must be taken to avoid sharp edges. If a harness must be routed over a sharp edge, then edge protection or a grommet shall be used to protect the harness from chafing. Tie-wrap harnesses to existing harnesses and structures at intervals of approximately 12 inches with labels in every accessible compartment.

#### 2.5 Pre / Post Installation Inspection Checklist

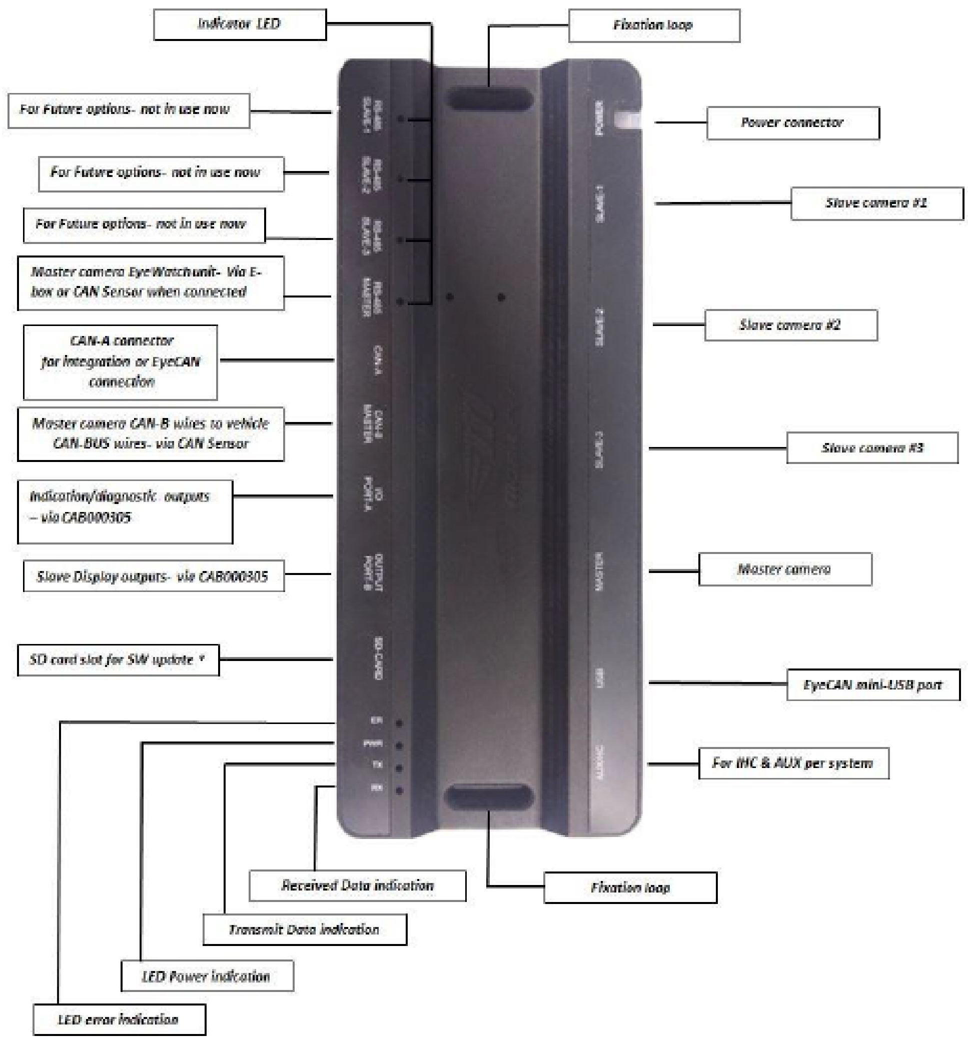
At the beginning and completion of each installation the Fleet Manager and the ROSCO installer must fill out a simple Pre / Post Installation checklist (Section 3.4) to confirm that the bus is in proper working order. If the bus is not fully functional the proper repairs should be completed *before* the installation begins. Upon completion, the fleet representative and ROSCO installer must fill out the Post Installation portion of the checklist to insure no damage has been done to the bus during the Shield+ installation.

## Section 3 – Diagrams, Technical Drawings & Packaging

### 3.1 – Component Placement Overview



# 3.2 - Junction Box Overview



## 3.3 – Vehicle Inspection Sheet

**Depot Location ___________________ Vehicle Number ___________________**

**Installer Name ___________________ Date _____________________________**

| Bus System | Items to check | Transit Pre-Inspection | Vendor Pre-Inspection | Transit Post Inspection | Vendor Post Inspection | Comment |
|---|---|---|---|---|---|---|
| Windows/Windshield | Not Cracked | | | | | |
| Windshield Wiper | Operational | | | | | |
| Engine (Noticeable Damage) | Operational | | | | | |
| Front Door | Operational | | | | | |
| Rear Door | Operational | | | | | |
| Destination Sign | Operational | | | | | |
| Wheelchair Lift | Check for power | | | | | |
| All Interior lights | Operational | | | | | |
| Bus Panels | Check for cracks or marks | | | | | |
| Stop Request Sign | Operational | | | | | |
| Heating & Air Conditioning | Operational | | | | | |
| Horn | Operational | | | | | |
| Signals & Flashers | Operational | | | | | |
| Speakers | Operational | | | | | |
| Parking Break | Operational | | | | | |
| Circuit Break & Fuses | Not tripped or blown | | | | | |
| Overhead Blower Motor | Not loose/Hardware not missing | | | | | |
| Exterior Panels | All panels and windows latched | | | | | |
| Clean Bus | All trash & debris removed | | | | | |

**Rosco Representative ______________________ Date______________________**

**Transit Bus Representative___________________ Pass # ___________________**

## 3.4 – Shield+ Packaging


## 3.5 – Packaging Complete Overview

Peripheral Package

E-Box

Junction Box

Center Display & Eyewatch

Front Pedestrian Displays

Front Sensor (Camera)


Ituran

Imobileye

Power Junction Box

Accelerometer

Power Adapter

CAN Harness

# Midbox Kit

Rear Sensor (Camera)

Mid-Point Box

Rear Sensor Mounting Bracket

Camera Mounting Hardware

# Section 4 – Panel Removal

## Make sure component placement has been verified before continuing

### Tools Needed:

- Philips Screwdriver
- Flathead Screwdriver
- Plastic Panel tool set
- Drill with extension
- 7-13MM socket
- T15-T30 Torx Bits

- Safety Glasses
- Garbage Bags
- Safety Vest
- Pre-Installation checklist completed

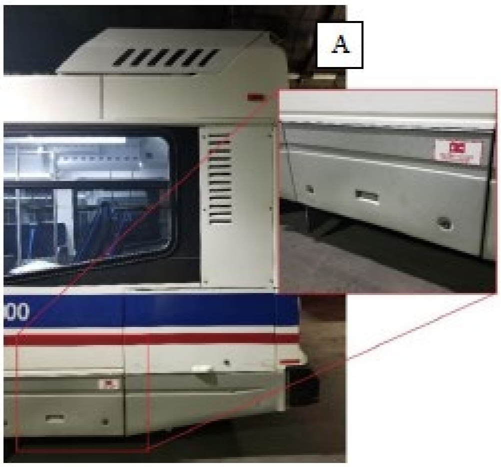
**Do not continue until Pre-inspection checklist is completed & signed by a Rosco installer & the Fleet Manager**

**Setup a work station with all components and tools together and organized. Keep all vehicle panels & screws together in labeled containers or bags to ensure vehicle re-assembly is correct with nothing missing**

**4.1 – Outside Panel Removal:**

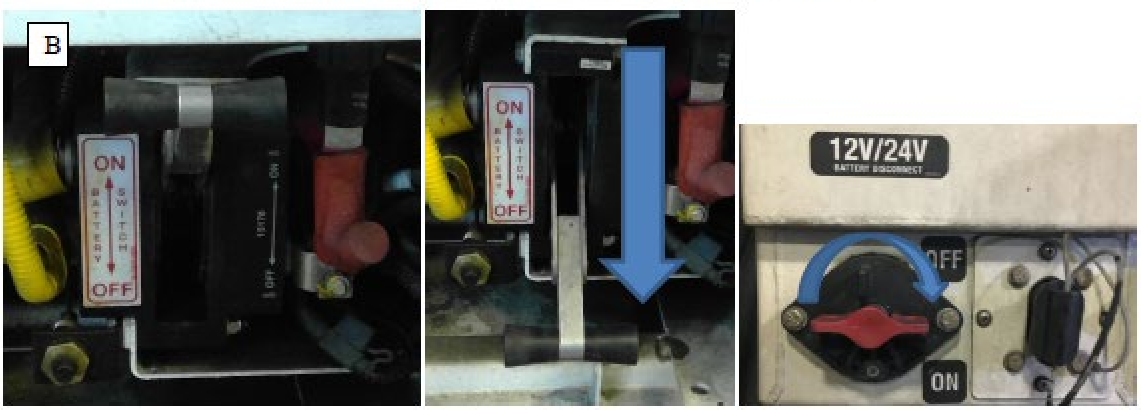
**Turn off the main battery switch before starting your install**

- Locate the Battery Disconnect Access door on the roadside Back (Or front) of the bus (A)
- Turn the battery disconnect switch to off (B)





Please Note: Location & switch may vary vehicle to vehicle



## 4.2 Interior Panel Removal

- Remove the screws located on the top panels of the bus. Repeat this process for both sides of the bus (Photo 2 & Photo 3)
- Photo 2 shows a plastic cover hiding the screws. Carefully remove this with a panel tool to gain access to the screws
- Locate the electrical cabinet and radio cabinet, then remove any screws securing them to the bus (Photo 4)

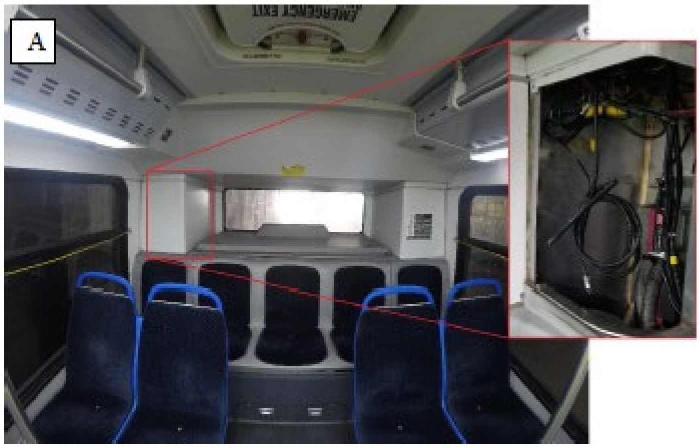
If working on an electric bus use extreme caution near cables that are orange. These are the vehicle's high voltage lines.




*Cabinet location May Vary*

## Interior Panel Removal (Continued):

- Remove the panel's in the rear of the bus. This will give you have access to rear camera entry points (Photo A)
- Remove any screws securing rear storage and/or electrical cabinets in the rear of the bus
- Rear panels completely removed (Photo C)





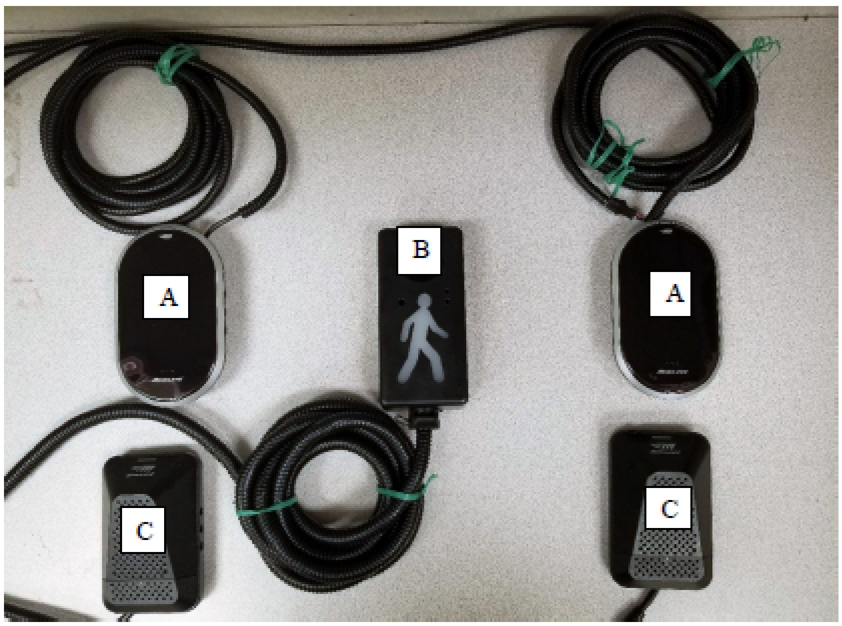
# Section 5 – Harness & Component Branches

*Front Branch*

**Tools Needed:**

| | |
|---|---|
| Flush Cutters<br>Plyers<br>Philips & Flathead Screwdriver<br>7MM-15MM Sockets<br>Precision Philips & Flathead | Zip Ties<br>Electrical Tape<br>3M Double side tape<br>Wire Loom<br>Plastic Panel Tool Set<br>Nylock & threaded inserts |

**Components Needed:**




**A – Left & Right Pedestrian Display**
**B – Center Display (Eyewatch)**
**C – Corner & Master Camera**

Installer Tip – Cover the front defrost with masking tape to prevent tools or screws from falling

## 5.1 – Front Branch Overview

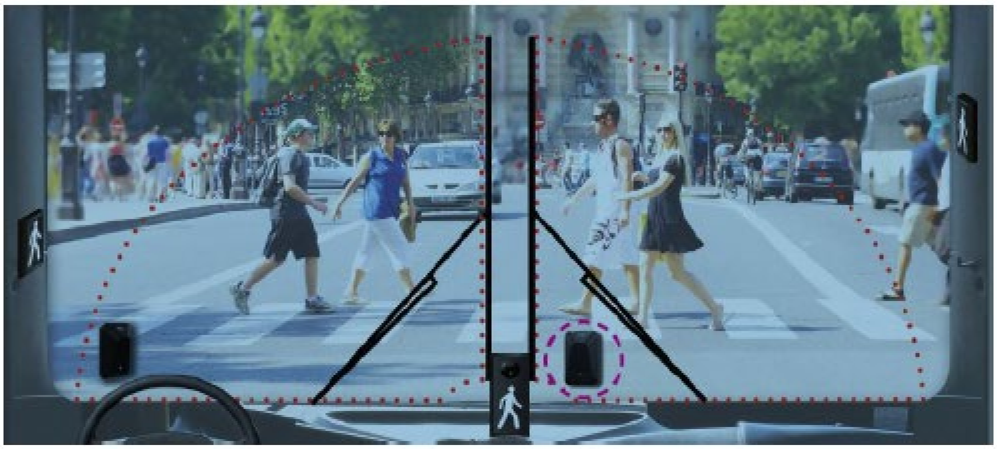
**Please take note of component mounting before continuing**


**Component placement MUST be verified & approved by the fleet manager before permanently mounting**

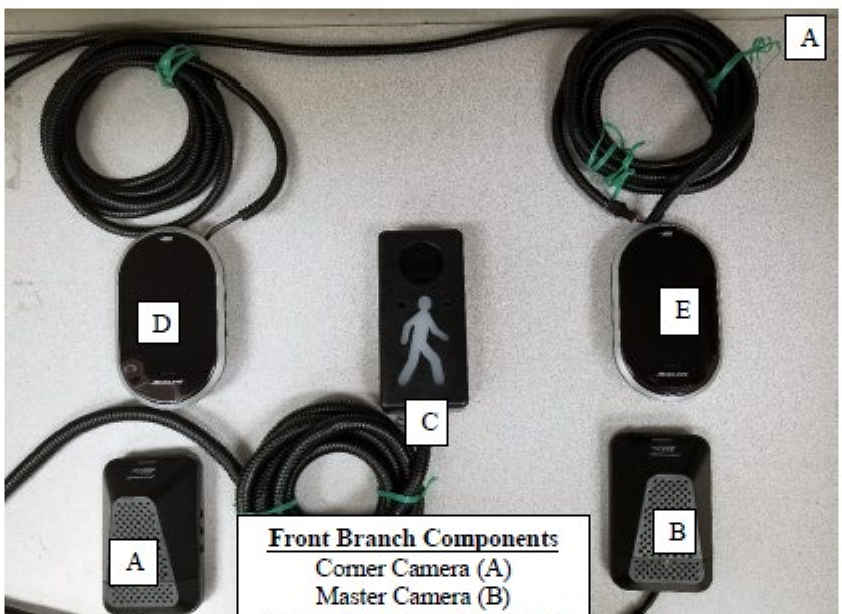
*Mounting all windshield components before routing the harness will allow you to store cable slack away from the driver*

## 5.2 - Front Branch Components:

*Make sure all front Sensors (Cameras) are mounted INSIDE the wiper swipe line __using the appropriate template__*



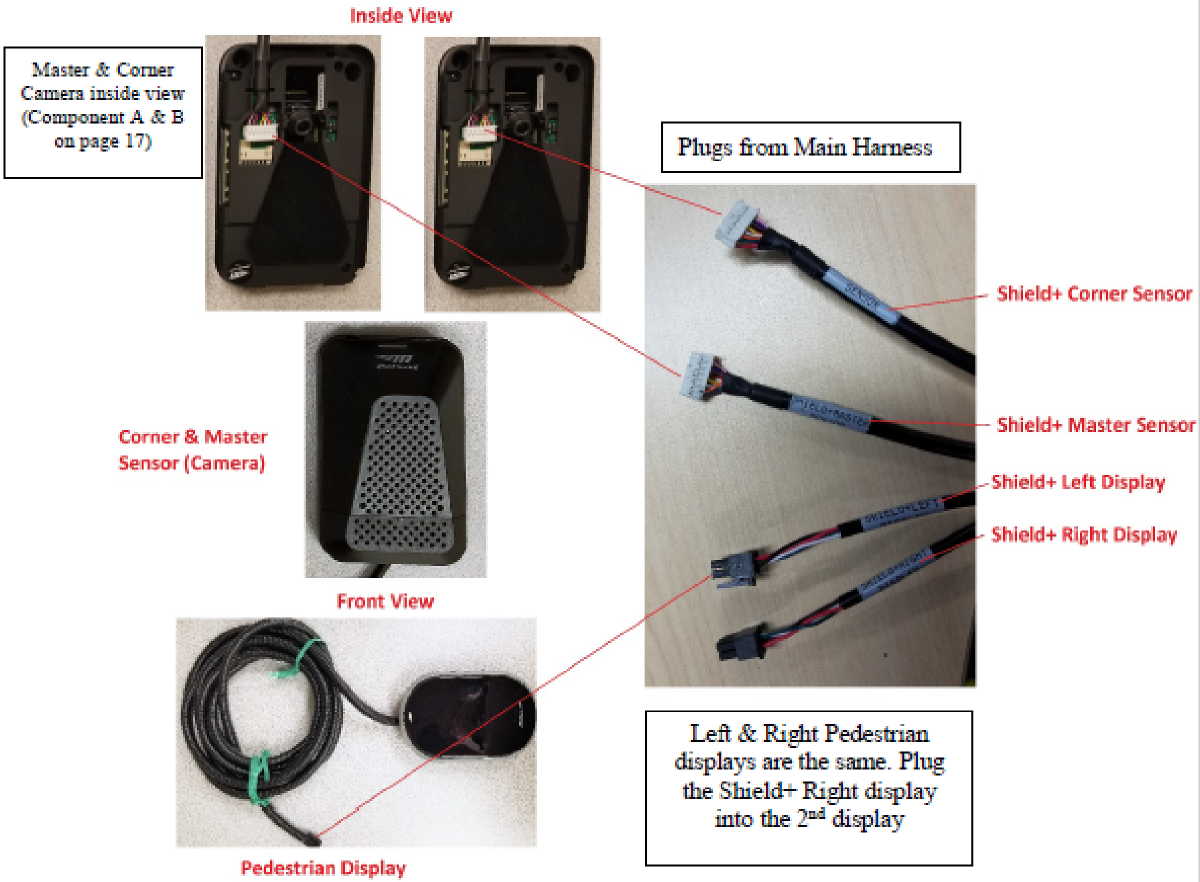
The Front Branch will be all windshield mounted components (Photo A)




**<u>Front Branch Components</u>**
Corner Camera (A)
Master Camera (B)
Center Display, Eyewatch (C)
Left Pedestrian Display (D)
Right Pedestrian Display (E)

## 5.3 - Front Branch Connections:

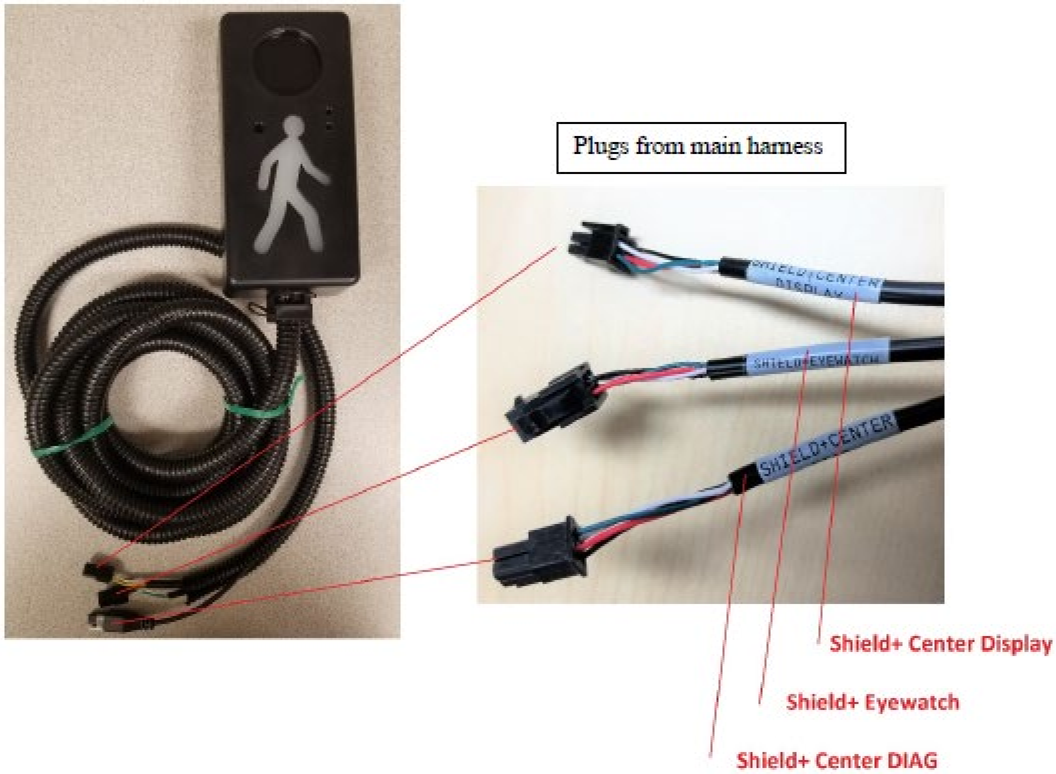
### 5.3.1 Sensor (Camera) & Pedestrian Display Connections:




The front sensors have to be adjusted for calibration after the install. Leave the covers removed from the sensor until calibration is complete

Full Calibration instructions can be found on section 15

## 5.3.2 - Center Display & Eyewatch Connection:




*Displays Mounted in line with the driver mirrors, facing the driver*

## 5.4 - Front Sensor (Camera) Mounting:

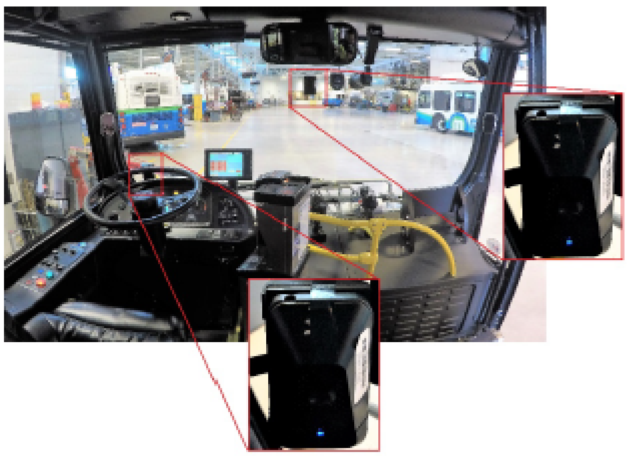
**Sensor mounting will vary with different buses & requests from Fleet Managers and/or Safety Inspectors. Use this guideline as a general guide for mounting locations**

ALWAYS CONFIRM MOUNTING LOCATIONS BEFORE SECURING SENSORS & DISPLAYS

***********Make Sure to use the Appropriate templates***********

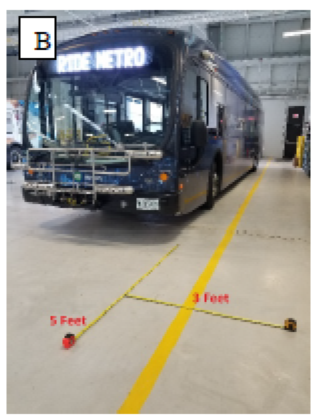
VHB Tape should only be applied when windshield temperature is within 50°F-100°F (10°C-38°C) to allow proper curing of mounting adhesive pads

The front corner camera must be installed within 30cm (~12in) from the edge of the driver's side windshield and at least 1.7m (~67in) from the ground. The corner camera MUST be installed at an angle to view the drivers blind spot in the front-left corner of the vehicle. To find this angle measure 5 feet from the front of the vehicle & 3 feet from the side (Photo B). Using one of several angle mounting brackets, (Photo 3) stick the camera to the windshield applying pressure for 30 seconds



The Front camera lens (Master Camera) MUST be installed inside the wiper swipe and as close to the center of the vehicle as possible. An offset of 10-15cm (~4-6in) from center of vehicle is allowed. The Front camera must be at least 1.2m (~47in) off the ground.
Water buildup on the windshield will cause the camera to generate false pedestrian readings. This camera has a viewing angle of 38 degrees.
Always mark the wiper line by turning on the windshield wipers and applying tape to the swipe area (Photo A)


Tape is applied to the windshield to show where the wiper swipe line ends

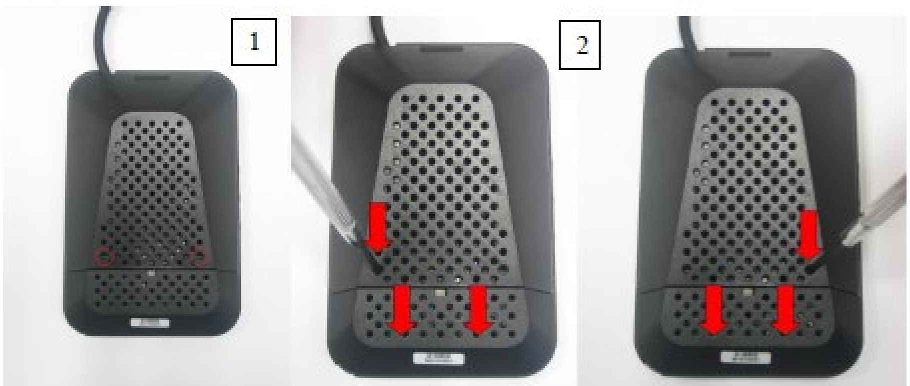



Tach Board placement will be 5x3 feet from the edge of the bumper which is the blind spot caused by the vehicles A-Pillar


Using one of the three brackets install the corner camera that will give you a view of the Tach Board as described in the previous step

## 5.5 – Front Sensor Cover Removal

1. Push down on the tabs located on the left and right side of the sensor (Photo 1 & 2)
2. Remove the lower cover of the sensor (Photo 3)
3. Using a small Philips screwdriver remove the two screws on the left & right side of the sensor

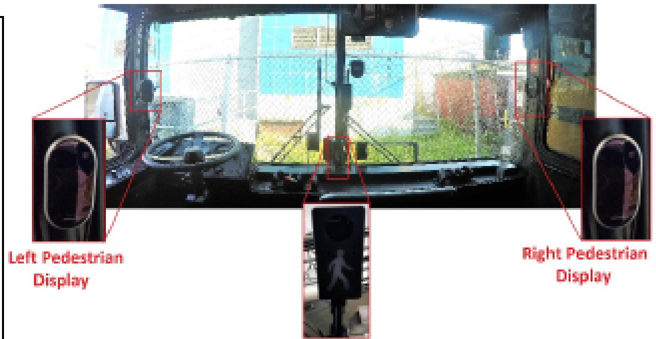




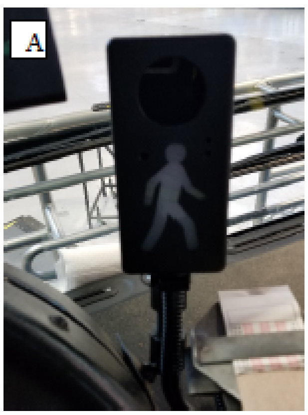
## 5.6 - Pedestrian Display Mounting:

If any damage occurs during the installation please notify the fleet manager immediately

We recommend mounting the Pedestrian displays in line with the side view mirror's so alerts are visible to the driver without obstruction to the driver. Displays can be mounted on a variety of brackets to fit the vehicle's needs. On some vehicles, the LEFT display will be mounted lower, depending on where the mirrors are located.



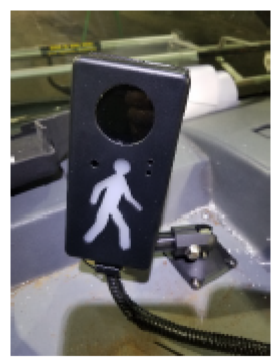

Mount the RIGHT pedestrian display in line with the curb side view mirror. **Make sure ALL pedestrian displays are angled towards the driver** You can mount the display using Nylock Nuts, Lock Washers or threaded inserts. Use extreme caution when drilling into the pillar. Drill slowly to avoid slipping with the drill



The Center display/Eyewatch (Photo A) is mounted on an adjustable pedestal (Photo B). The center display should be mounted close to the driver.

**Secure the Center display to the dash with Rivne's or the windshield with 3M double side tape**

The center display can be mounted to different locations on the bus as long as it's facing the driver & not causing a distraction



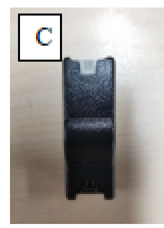
# Section 6 - Middle Branch

**Tools Needed:**

- Philips Screwdriver
- Flathead Screwdriver
- Plastic Panel tool set
- Drill with extension
- 7-13MM socket
- T15-T30 Torx Bits
- Zip ties
- Drill Bits

**Components Needed:**









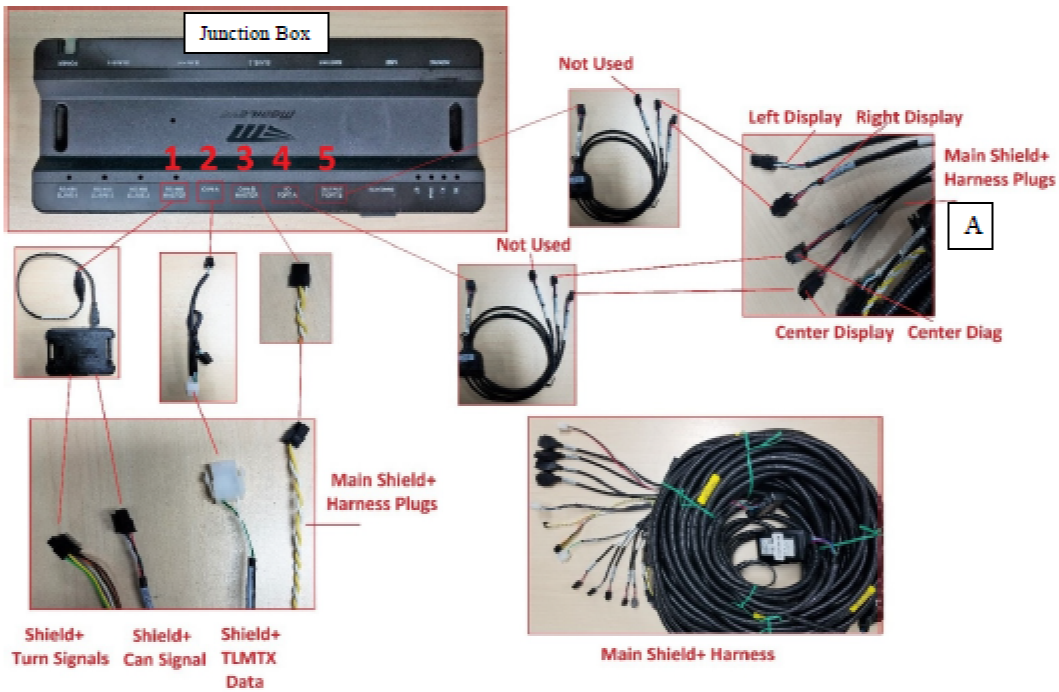

A – Starlink
B – Junction Box
C - Imobileye
D – Port A & Port B plug (J15 & J16)

E – E-Box
F – Powerhub
G – Accelerometer

## 6.1 - Middle Branch Complete Overview:

**Please take note of component connections before continuing**

Once all front branch components are mounted, follow the diagram below for component connections to the junction Box




| The Main Shield+ Harness Plugs (Photo A) is showing the Middle Branch connectors. |
|---|

**<u>Junction Box Wiring Numbers</u>**

1- RS-485 MASTER – MOBILEYE 5 TO E-BOX CABLE
2- CAN-A – SHIELD+ TLMTX ADAPTER PLUG
3- CAN-B MASTER – CAN WIRING PLUG
4- I/O PORT-A – MOBIEYE SHIELD+ FOR LED DISPLAY ADAPTER
5- OUTPUT PORT-B – MOBILEYE SHIELD+ FOR LED DISPLAY ADAPTER

**NOTE:** All harness branches and terminations will be labeled for identification during installation and future maintenance.

## 6.2 - Middle Branch Components:

- These components are usually mounted inside the electrical cabinet. These cabinets can be located in the front, middle, or rear of the bus as describes in the panel removal section 4.1. Photo A are all components mounted and connected in the middle harness section. Photo B are the connections from the harness

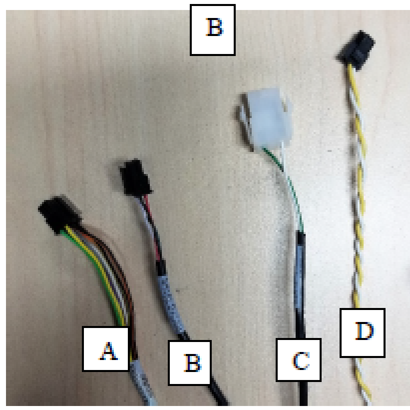
Pedestrian Display Connections

A

Junction Box

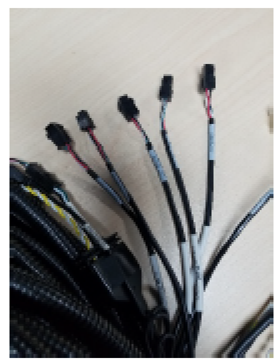
E-Box

B




The Middle Harness Branch are labeled as the following:

(A) Shield+ Turn Signals (B) Shield+ Can Signal (C) Shield+ TLMTX Data (D) Can Wires



Pedestrian Display Plugs

## 6.3 - Middle Branch Connections:

### 6.3.1 - Pedestrian Display Connections:

- Connect the Plug on the main harness (Photo B) labeled Left Display & Shield+ Right Display to Port A & Port B (Photo A)


Left Display

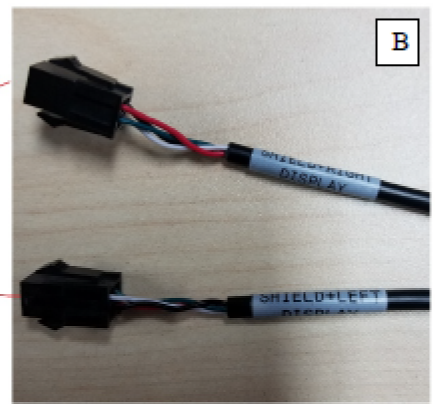
Right Display

Not Used

Please Note:

Plug 1 on the Port A & Port B plugs are not used.

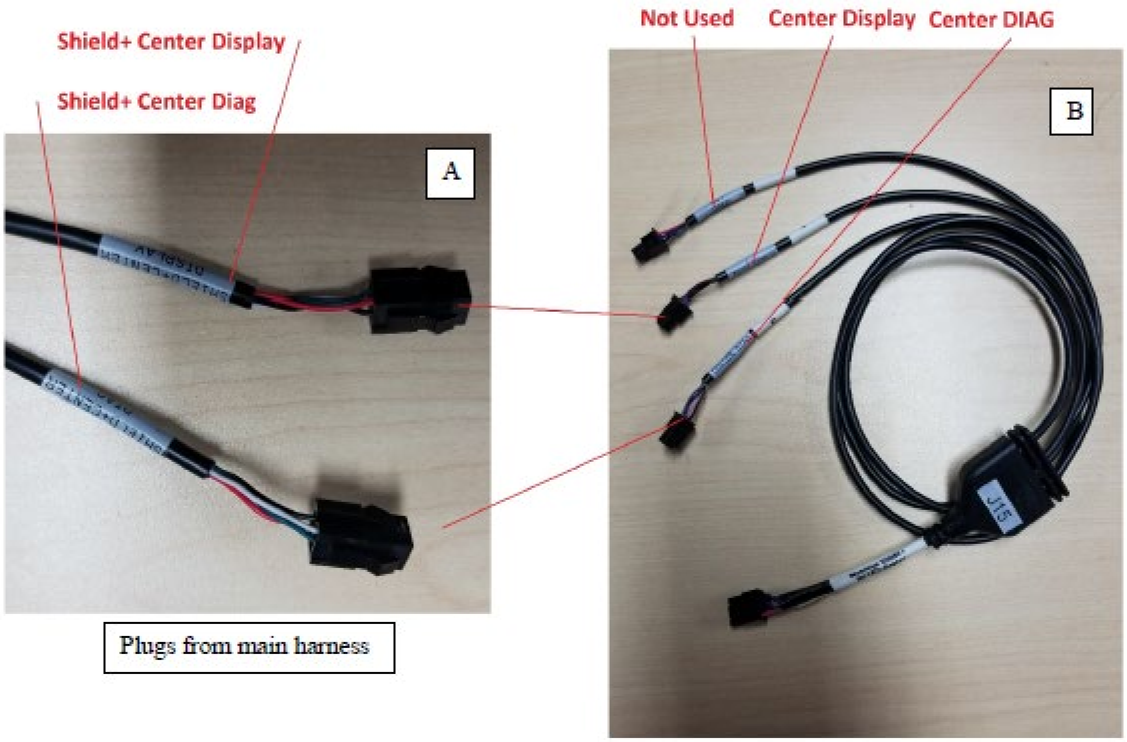
These cables may also be labeled J15 & J16




Plugs from main harness

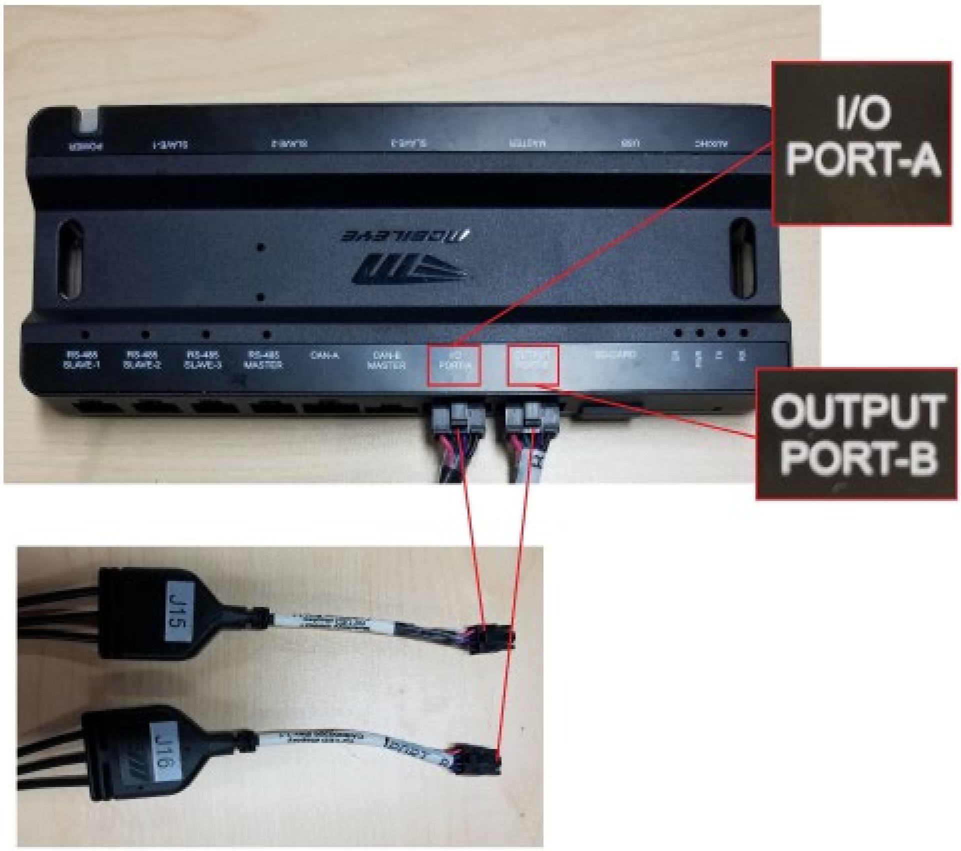
## 6.3.2 - Center Display & Eyewatch Connection

- Connect the Shield+ Center Display & Shield+ Center Diag plugs (Photo A) to the Center Display & Center Diag plugs on the J15 (Port A) Cable (Photo B)



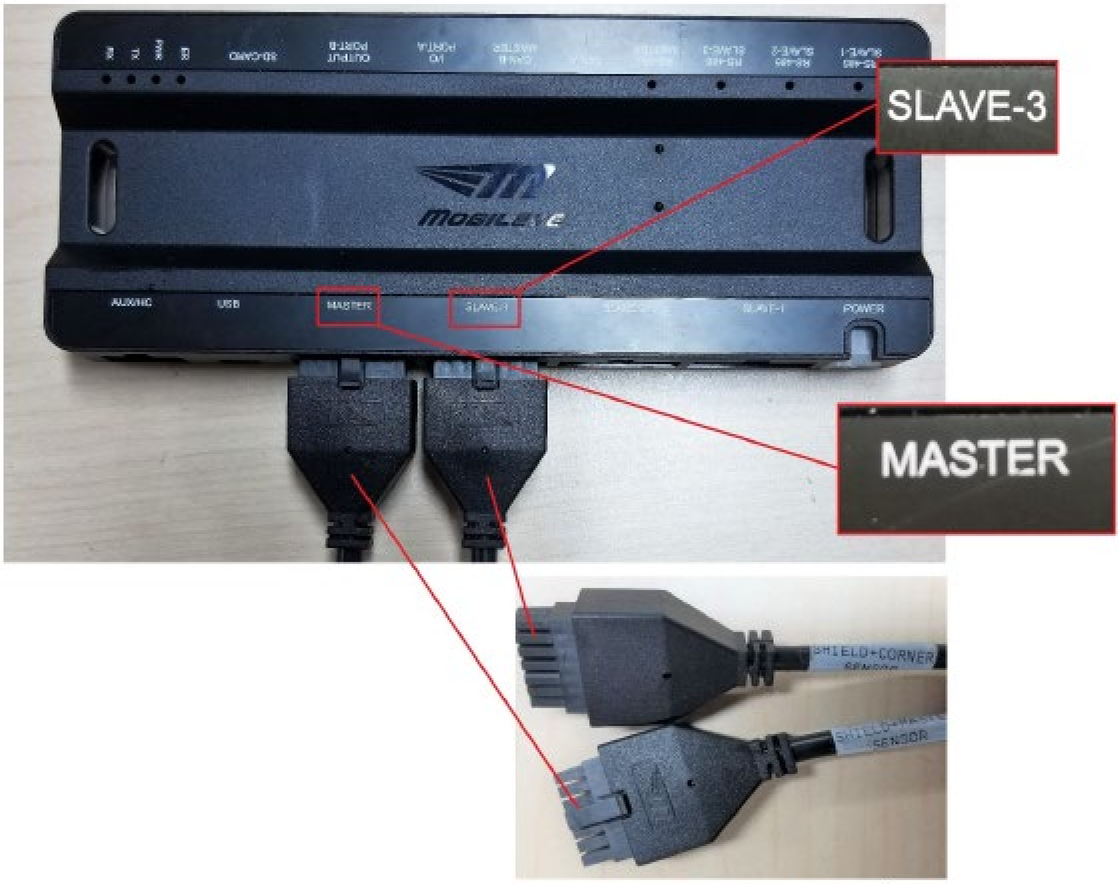
**Center Display & Eyewatch Connection (Continued):**

- Connect the J15 (Port A) & J16 (Port B) plugs into the Junction Box
- Connect the center display & Eyewatch (J15) into the I/O Port A
- Connect the Left & Right pedestrian displays (J16) into the Output Port B



### 6.3.3 - Front Sensor (Camera) Connections:

- Connect the plug labeled “Shield+ Master Sensor” to the “Master port on the junction box
- Connect the plug labeled “Shield+ Corner Sensor” to the “Slave 3” port on the Junction Box



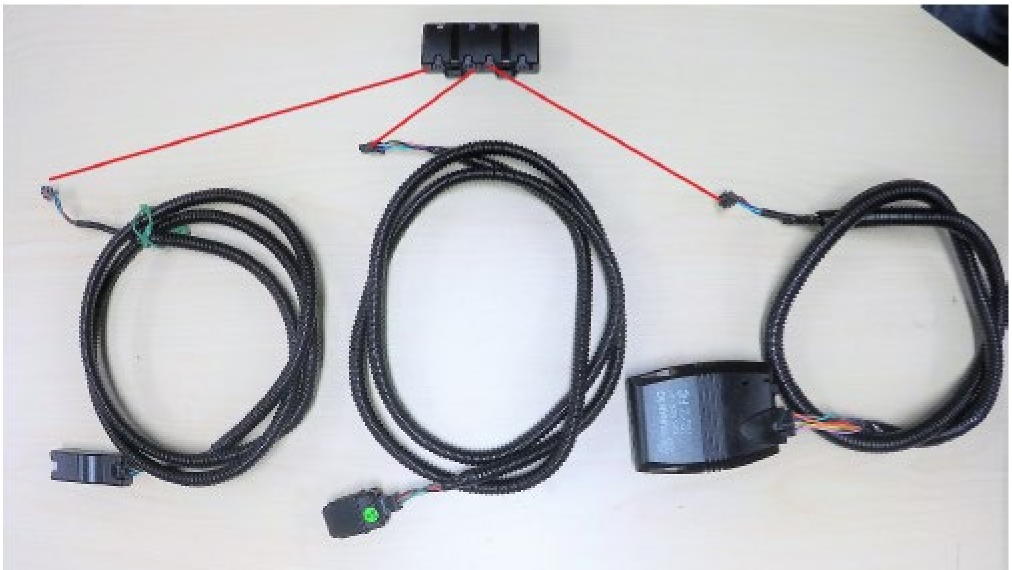

Plugs from main harness

## Section 7 – Telematic Components:

### 7.1 – Telematics Overview

The Telematic components are located above the driver in the overhead destination sign compartment

- Connect all telematic components (Photo B, C & D) to the power Hub (Photo A)




Power Hub

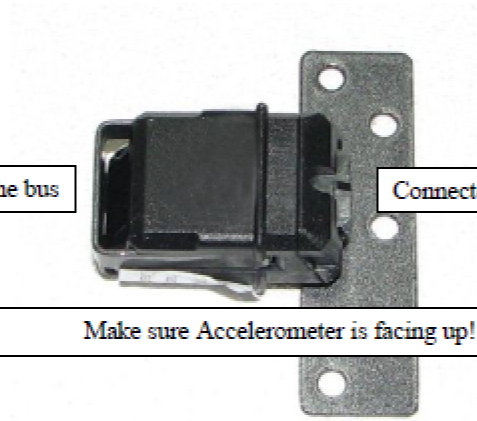

Accelerometer


Ituran (Starlink)

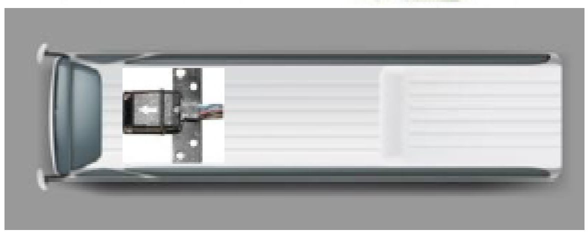

Immobilize

## 7.2. – Accelerometer

Mount the Accelerometer horizontal with the connector facing the rear of the bus. Make sure to mount the Accelerometer to a solid and secure piece of metal.




Top Mount view



Side view

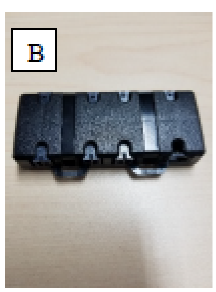
## 7.3 – Starlink

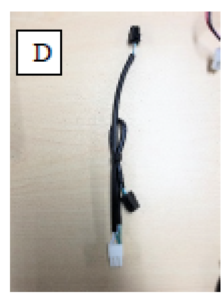
- For the best reception please install the StarLink device in the top part of the front dashboard.
- Make sure that the GPS side face up
- Make sure that there is no metallic surface above the Starlink
- Make sure the Starlink is facing the correct way (A)
- Connect the Starlink to the power hub as shown in the picture on section 7.1

A

## 7.4 – Immobilize

- Connect the I-Mobileye (A) to the power hub (B).
- Connect I-Mobileye extension harness (C) to the I-Mobileye (A)
- Connect I-Mobileye extension harness (D) to the CAN A port on the junction box.





# Section 8 – Rear Branch

Make sure component placement has been verified before continuing

**Do not continue until Pre-inspection checklist is completed & signed by a Rosco installer & the Fleet Manager**

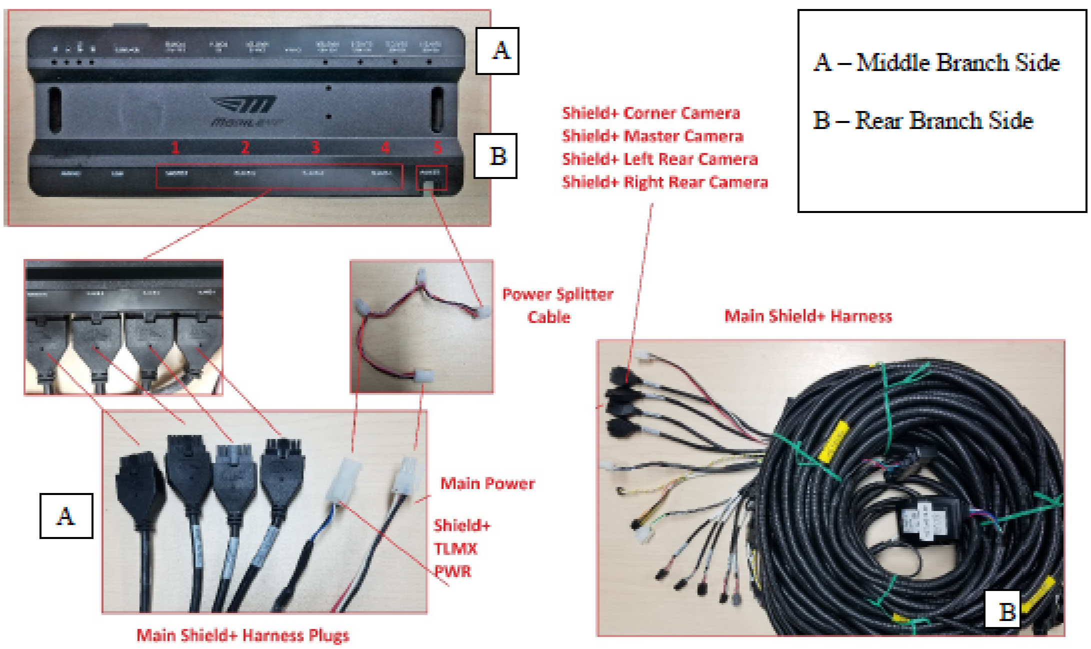
Use extreme caution when drilling into the vehicle. Make sure to check for clearance before making holes for brackets or cable routing.

Make sure you have a vehicle template for your application before continuing

Make sure the Appropriate Template is used for EXACT rear sensor mounting location

Template Part Numbers can be found in Section 12

## 8.1 - Rear Branch Connection Complete Overview




| | |
|---|---|
| The Main Shield+ Harness Plugs (Photo A) is showing the rear branch connectors. | **<u>Junction Box Wiring Numbers</u>**<br>1- MASTER – Connect to the SHIELD+ MASTER CAMERA plug<br>2- SLAVE 3 – Connect to the SHIELD+ CORNER CAMERA plug<br>3- SLAVE 2 – Connect to the SHIELD+ LEFT REAR CAMERA plug<br>4- SLAVE 1 – Connect to the SHILED+ RIGHT REAR CAMERA plug |

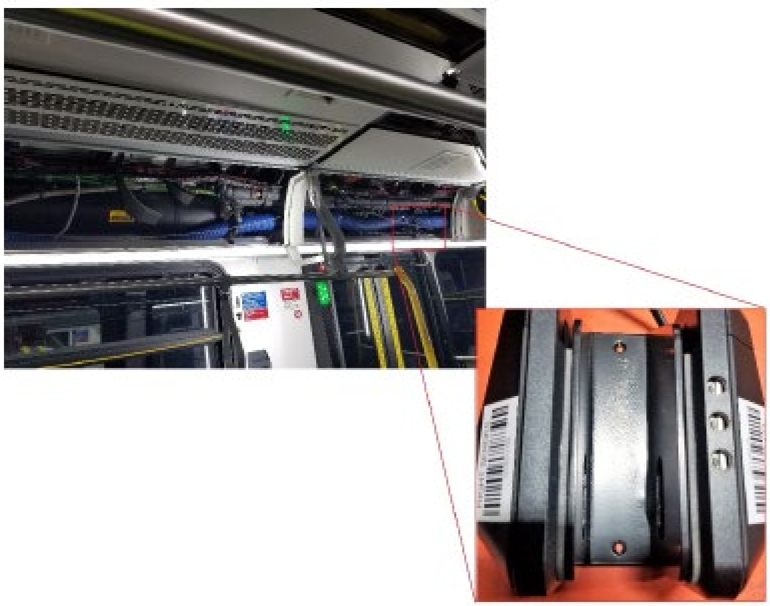
## 8.2 – Rear Branch Components

*The Coax coupler will already be attached to the rear sensor (Camera)*


Mid-Point Box


Rear Camera


Coax Coupler

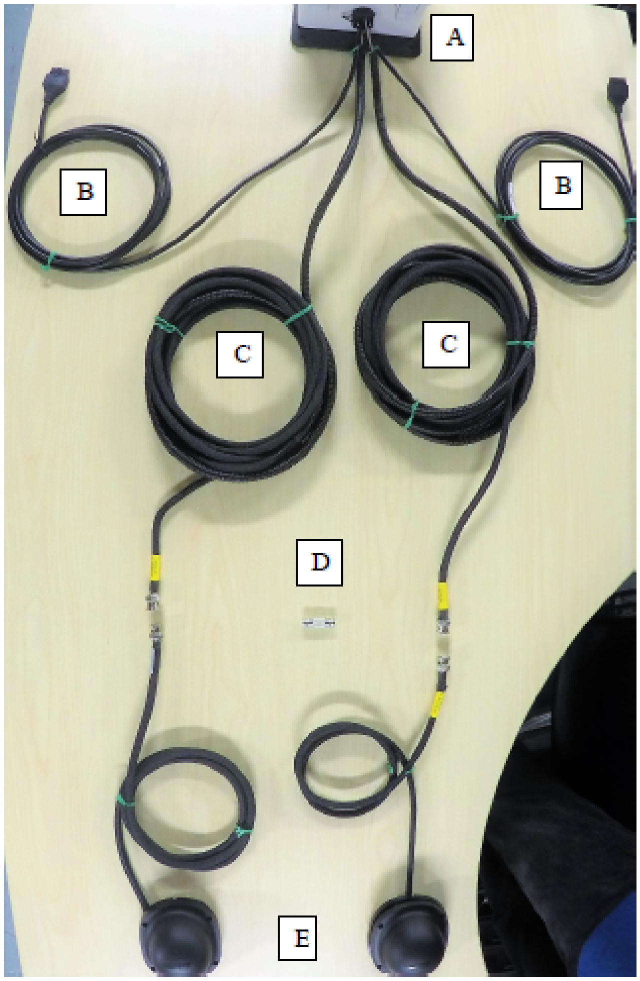


***The Mid-Point box should be mounted in the rear of the bus, no more than 17 feet from the rear cameras***

## 8.3 - Rear Branch Component Connection:

Plug B will connect to main harness routed through the vehicle

Plug C will connect to the rear sensors (Cameras)




"D" is the Coax Coupler that will connect the coax cable on the rear sensor to the coax cable on the Mid-point box (Will be attached when harness is put together

A – Mid Point Box

B – Junction Box Extension Cable

C – Rear Camera Extension Cable

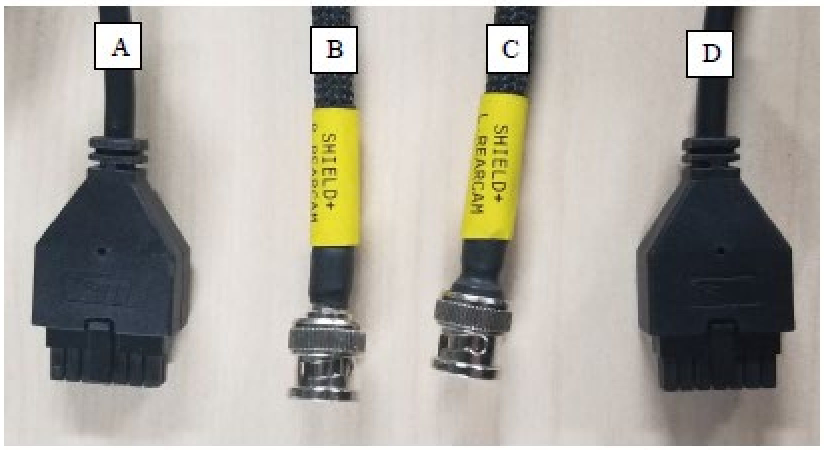
D – Coax Coupler

E – Rear Sensor (Camera)

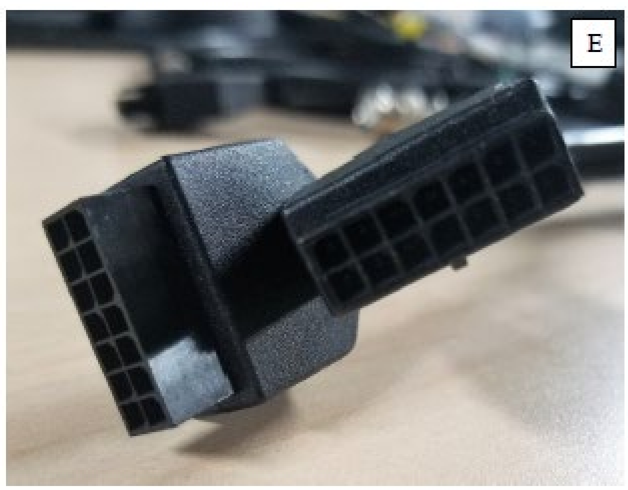
### 8.3.1 - Mid-Point Box Connections:

**The four cables coming out of the Midpoint box are:**

- A – Connect to the main harness plug labeled Shield+ Left Rear Sensor (Photo E)
- B – Connect to the Right Rear Sensor (Camera) with the Coax Coupler shown in section 8.3
- C – Connect to the Left Rear Sensor (Camera) with the Coax Coupler shown in section 8.3
- D – Connect to the Main harness plug labeled Shield+ Right Rear Sensor (Photo E)

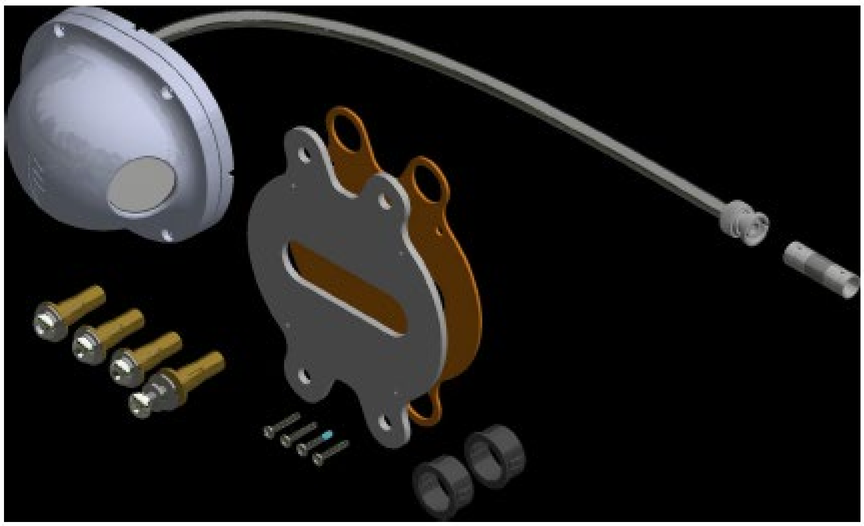






## 8.3.2 Rear Camera Complete Overview

Rosco will provide a vehicle specific template for exact component location. Please see section 12 for all vehicle specific template part numbers



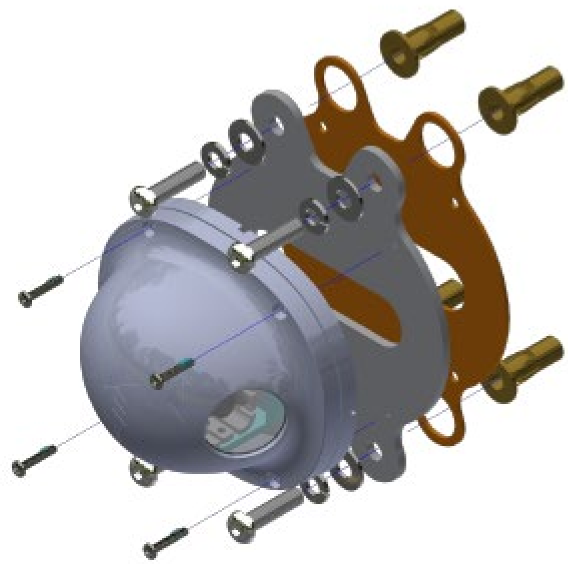

## Rear Sensor (Camera) Mounting Continued:

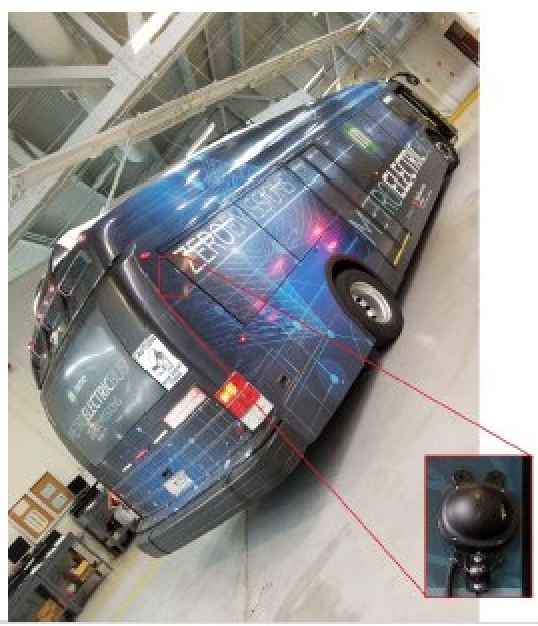
Depending on the vehicle there are several mounting brackets to use for rear sensor installs


Each bracket is used for left & right-side sensors by using the opposite sides of the bracket

- A - MTA bus
- B - Rear sensor with AUX camera
- C – Standard rear sensor bracket
- D – Rear sensor with AUX camera mounted

### 8.3.3 - Rear Sensor Mounting





## Section 9 - Harness Installation:

### 9.1 – Front Harness Routing:

*The Vehicle described in the photo below has the Electrical cabinet behind the driver. Keep in mind location and routing will vary with different vehicles*

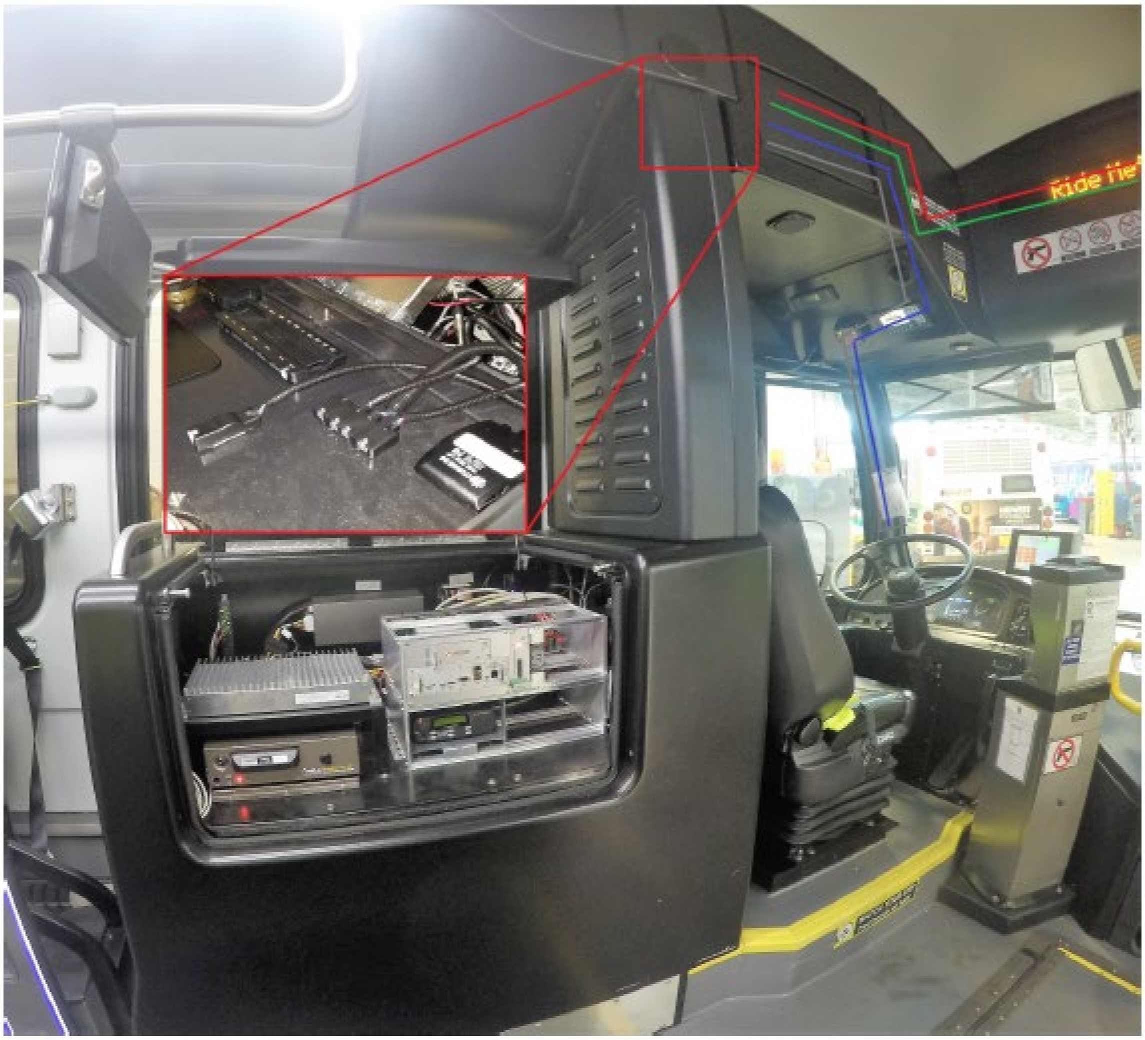
- For the corner camera & pedestrian display (Drivers Side), route the cable up the A-Pillar into the above compartment, and into the electrical box (Gray & Blue)
- Route the center display and master camera up through the above compartment (Red & Green)

**Always use a grommet and loom when routing cables. Make sure the harness is secured with a zip tie and does not cause any distraction to the driver**


Gray- Corner Camera
Blue – Left Pedestrian Display
Red – Master Camera
Green – Right Pedestrian Display

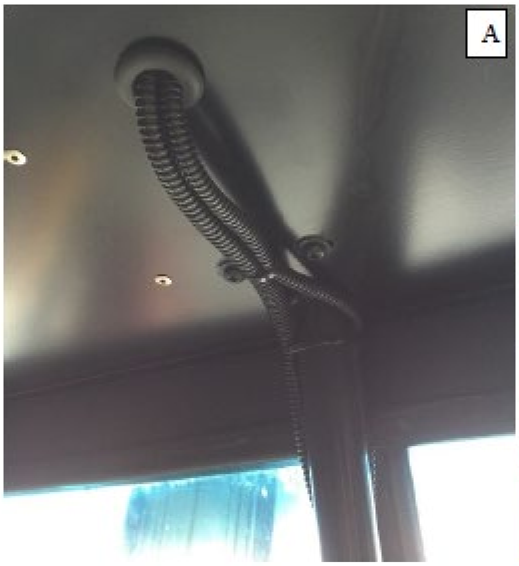
## Front Harness Routing (Continued):

**Front harness branch routed to Electrical cabinet where Shield+ components are mounted**



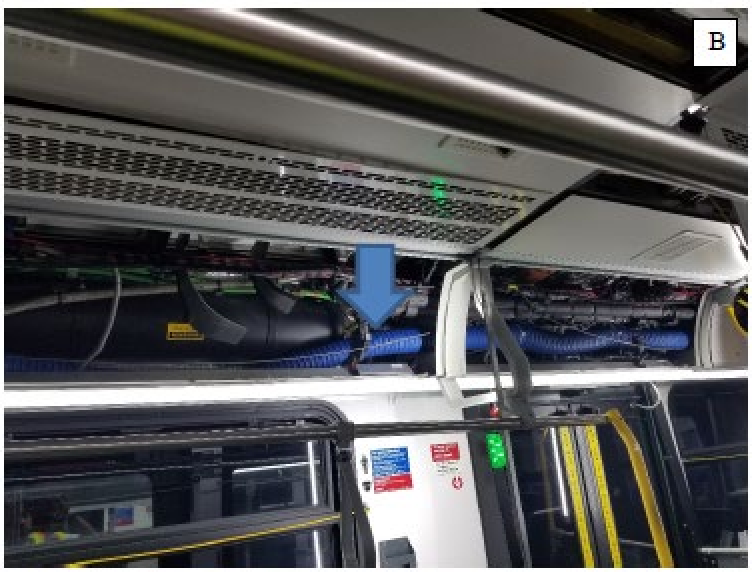
## Front Harness Routing (Continued):

- Always use a grommet and loom when routing cables to inside compartments. Make sure the harness is secured with a zip tie and does not cause any distraction to the driver (Photo A)
- When routing across the dash to the A-Pillar, secure the cable with a 3M Zip Tie holder (Photo B)



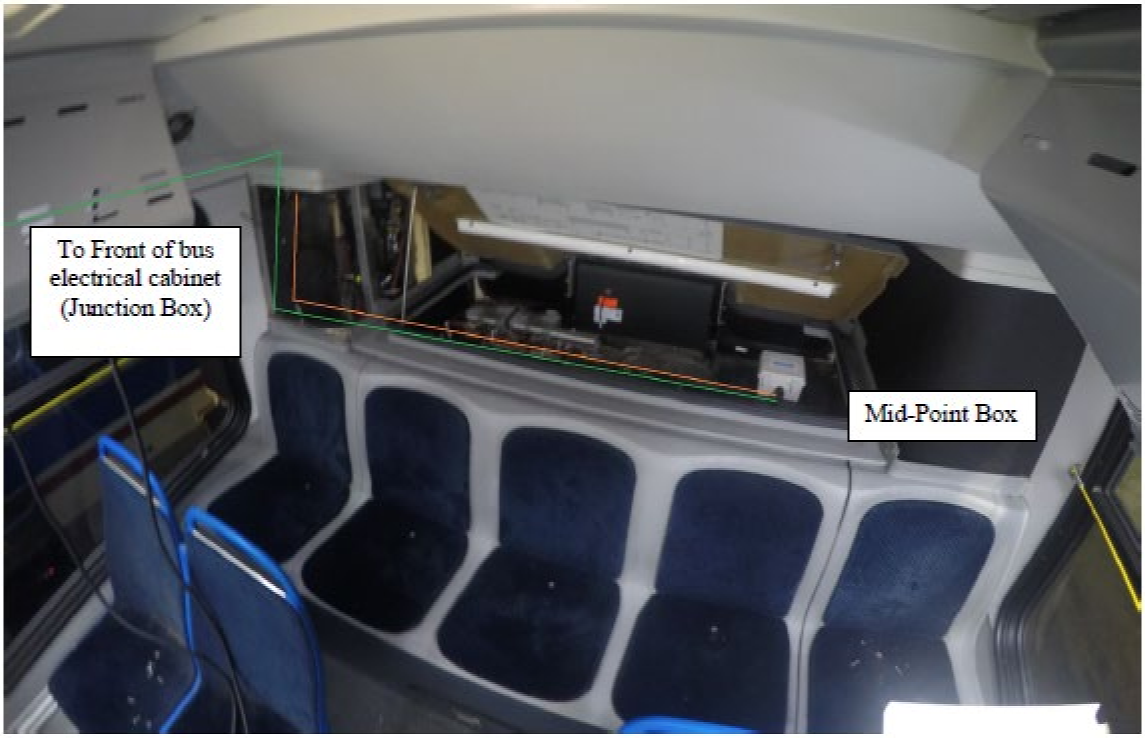

## 9.2 Middle Branch Harness Routing:


- With all side panels removed, route the cable along the factory harness (Photo A)
- Secure the Shield+ Harness to the factory harness with zip ties every 12 inches
- Make sure to not interfere with factory heating & Ac vents when routing wires (Photo B)



## 9.3 - Rear Harness Routing:

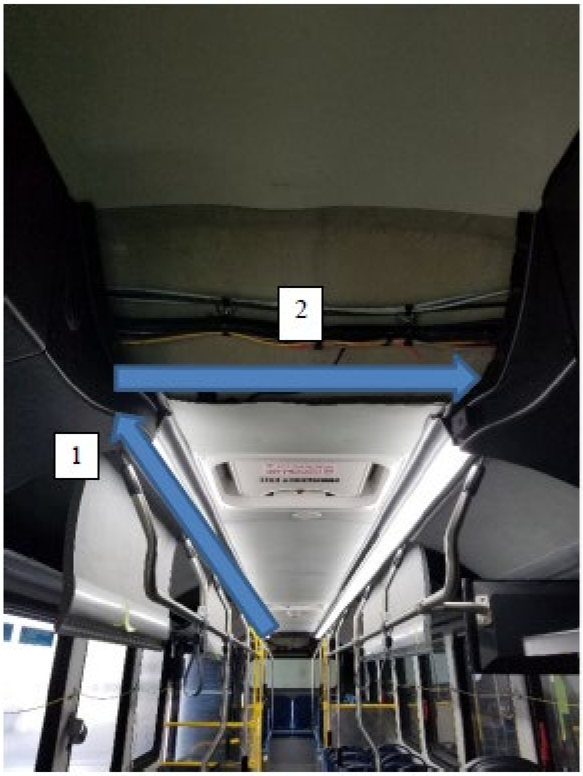
The photos below show different mounting locations for rear mounted components & wire routing

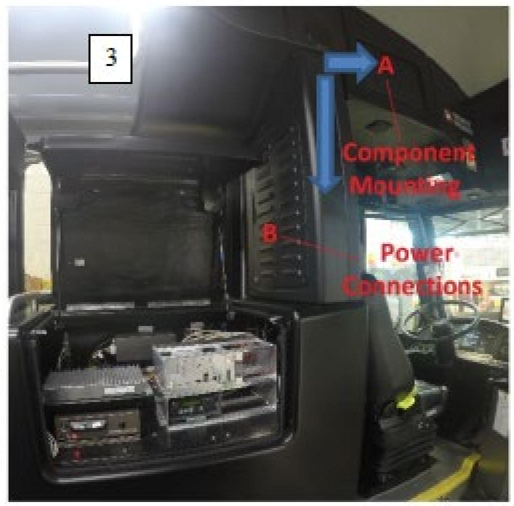


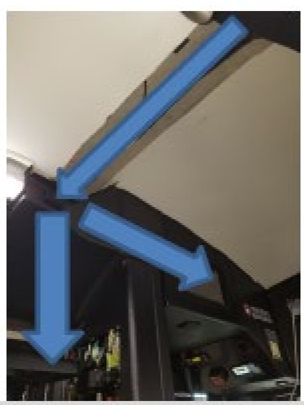

Orange – Rear camera cable to Mid-Point Box
Green – Extension cable from Mid-Point Box to junction box

## Rear Harness Routing (Continued):

- Route cables from rear to Front (Arrow 1)
- Cross over from curb side to drivers' side by removing the center panel (Arrow 2)
- When on the driver's side (Photo 3), route cables into the two junction boxes (A&B)



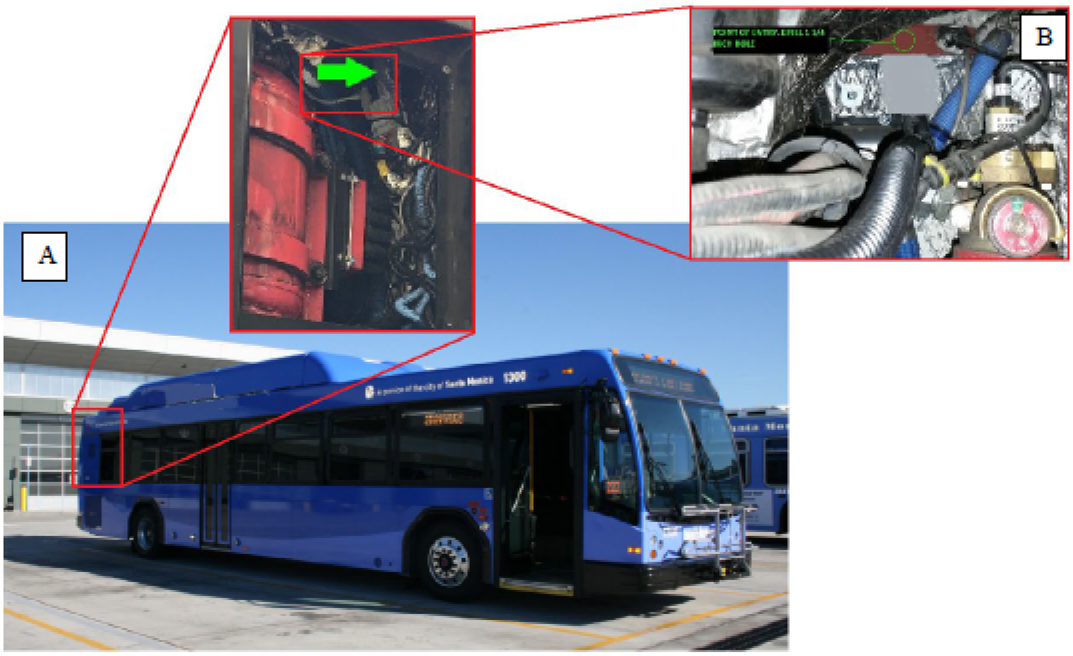



## Section 10- Camera Entry Point

### 10.1 – Rear Sensor (Camera) Entry Point:

1. Open any engine access door panel to access area where the entry point will be drilled.
2. This will be located on the side or rear of the bus (Photo A shows side entry)
3. Identify entry point location & check both side of the firewall to ensure no damage to existing harnesses or hoses. (Photo B)
4. Drill a pilot hole first to confirm entry hole will be in the right location.



**Rear Sensor (Camera) Entry Point Continued:**

- Run the wires through pre-drilled hole
- Seal the hole from both sides using Black Sikaflex 221 (Photo A)

The roadside harness MUST be protected by heat/fire resistance jacket due to the amount of heat generated by the exhaust. Run harness under and away from the exhaust system by follow existing OEM harness in the area

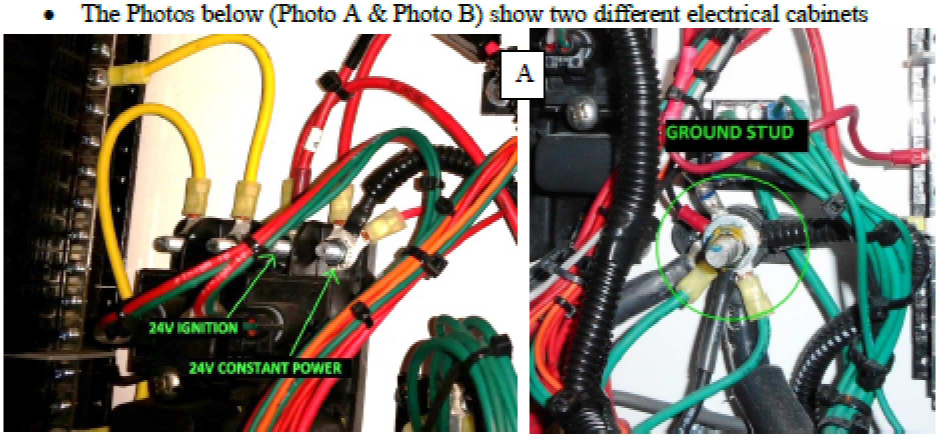

A

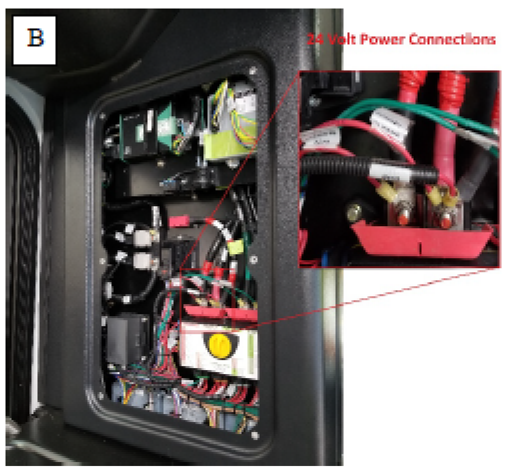
# Section 11 – Wiring

## 11.1 – Power, Ground, & Ignition

**MAKE SURE THE BATTERY DISCONNECT SWITCH IS OFF BEFORE MAKING YOUR POWER CONNECTIONS (SECTION 4.1)**

- Crimp ring terminals on the Constant, Ignition, & Ground wires
- The Photos below (Photo A & Photo B) show two different electrical cabinets




**If Splicing into a harness always use the Military Splice method and solder. NEVER USE TTAPS on power connections as they are not an MECP approved method**

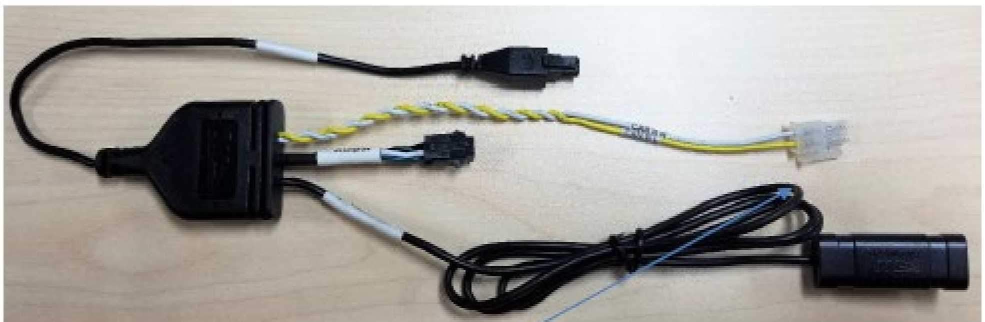
**If cutting and soldering wires, always protect the connection with heat shrink**

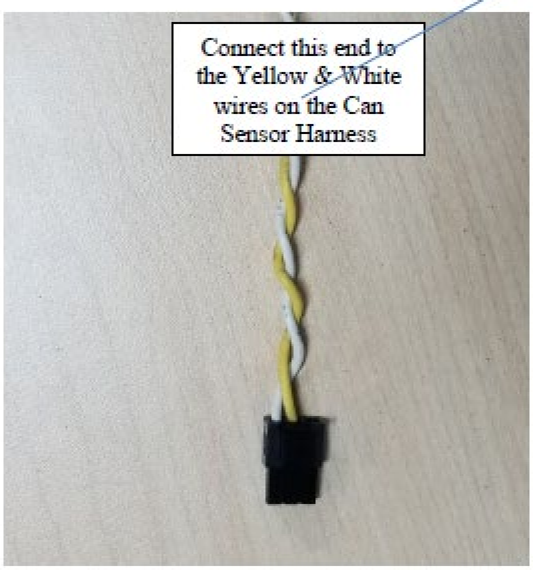
## 11.2 – CAN Connections

**Make your CAN connections before plugging the can sensor into the junction box!**

The CAN Bus network is an integral part of the harness. Connect the labeled harness wires to the corresponding terminals as follows and as shown in the pictures below:

**CAN SENSOR2 HARNESS**

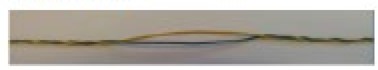




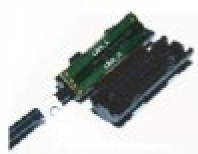

How to Install the CAN Sensor:

1. Identify the vehicle CAN-bus wires

2. Untwist the CAN-bus wires over a distance of about 5cm



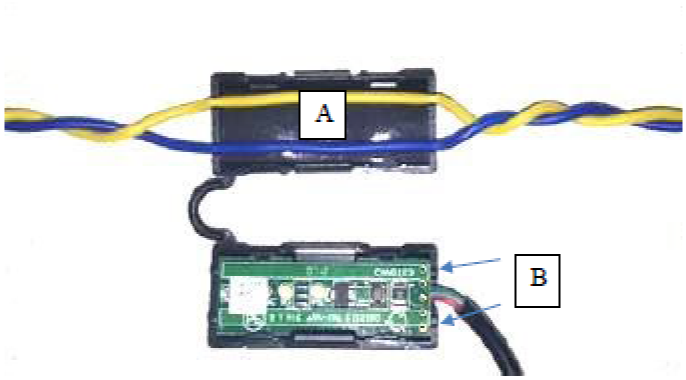
3. Simply place the CAN Sensor over the CAN-bus wires as labeled on the CAN Sensor module



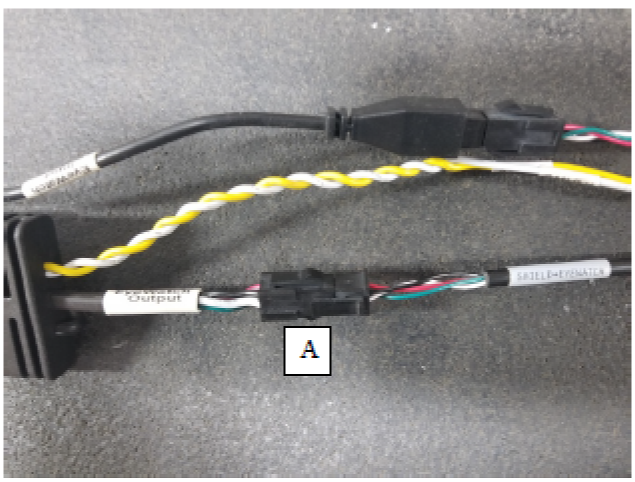
Plug this end into the junction box

**CAN Connections (Continued):**

- Locate the Vehicles CAN wires and untwist them to fit in the CAN sensor (A)
- Position the wires in the grove of the connector
- Pay attention to the CAN HI & CAN LOW markings on the circuit board (B)
- Secure the CAN sensor with zip ties to secure the connection (C)








- Connect the plug from the main harness labeled Shield + Eyewatch to the plug Eyewatch Output on the CAN sensor harness (A)

## 11.3 – Ebox

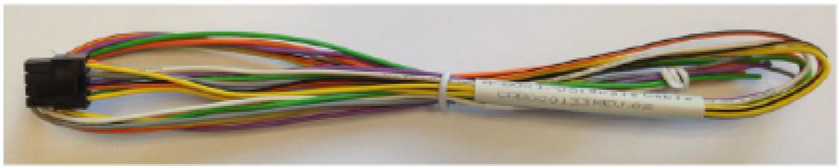
The Mobileye E-box (Enhancement box) is an adapter that allows us to install the Mobileye 6 system in any vehicle, regardless of CAN-bus availability.

The E-box supports up to 6 analog signals inputs and 2 analog outputs (for various devices/applications.)

The E-box can be used for a full Analog Mobileye 6 installation, for a Mixed CAN/Analog Mobileye 6 installation or just as a source for 2 additional analog outputs.

The E-box enables easier installation on vehicle with a limited variety of signals on the CAN-bus and/or with no CAN-bus and allows us to upgrade from an older Mobileye system using the existing wiring/connections.





| | Cable Label | Function | Connect to | Color |
|---|---|---|---|---|
| | A-box I/O Signals Cable (CAB000133) | Analog signals Input/output cable | A-box - Analog Signals I/O port | Multiple |
| 1 | "1" | Speed | Vehicle Speed Signal | Orange |
| 2 | "2" | High Beams | Vehicle High beams Signal | White |
| 3 | "3" | Brakes | Vehicle Brake Signal | Purple |
| 4 | "4" | Left | Vehicle Left Turn Signal | Green |
| 5 | "5" | Output 1 | | Yellow/Black |
| 6 | "6" | Wipers | Vehicle Wipers Signal | Gray |
| 7 | "7" | Output 2 | | Orange/Black |
| 8 | "8" | Right | Vehicle Right Turn Signal | Yellow |

## Section 12 – Vehicle Specific Information

| Bus Type | 12(24) Volt/Ignition | Electrical Box Location | Front Template Part # | Rear Template Part # | Photo Number |
|---|---|---|---|---|---|
| Proterra | | | | | A |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

# Section 13 - Articulated Bus

**Make sure component placement has been verified before continuing**

## Components Needed

Rear Camera

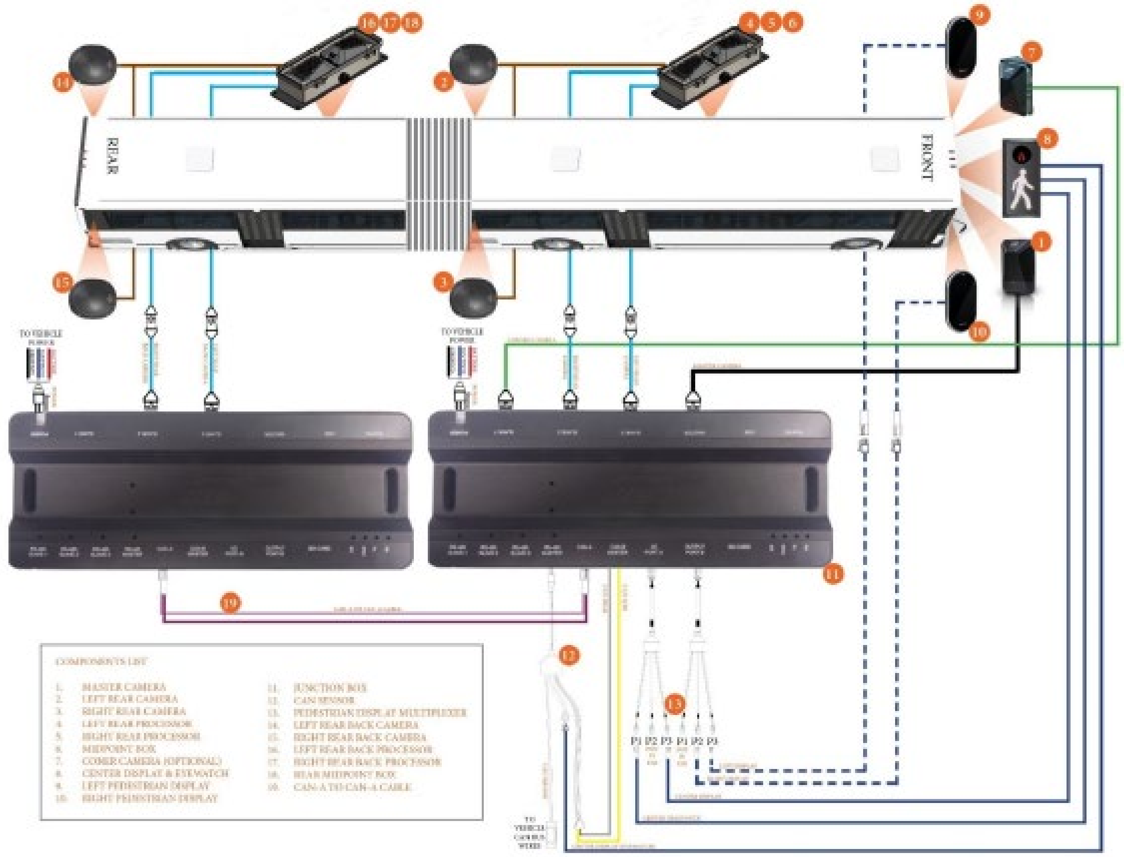
Junction Box #2

Rear Camera

Mid-Point Box #2

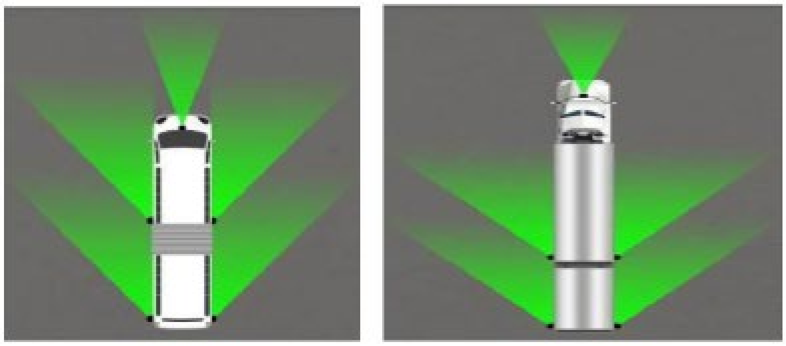
PACSH0002 Junction box connector

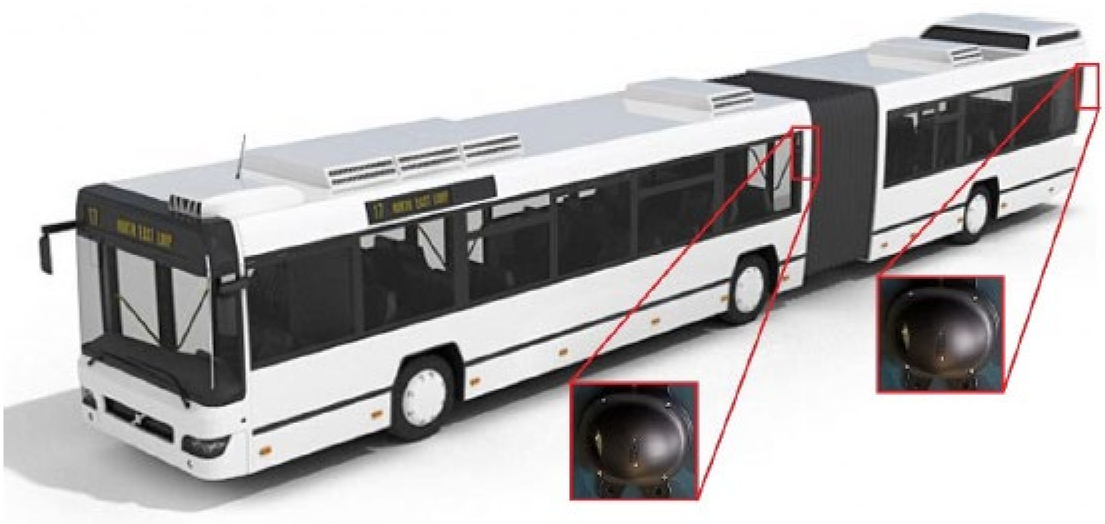
## 13.1 – Articulated Bus Component Placement Overview



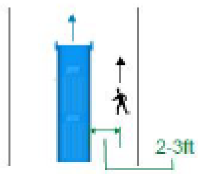
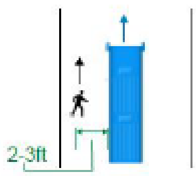
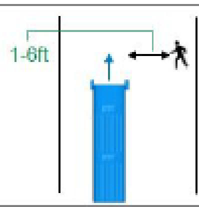
## 13.2 – Articulated Bus Camera Placement

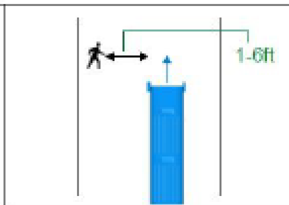
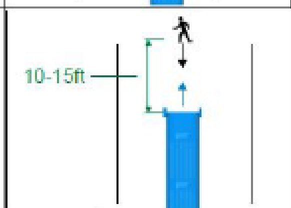
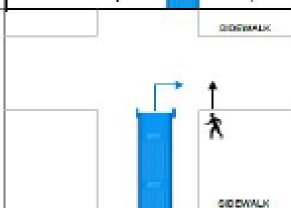
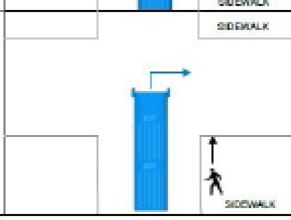
Articulated vehicle:

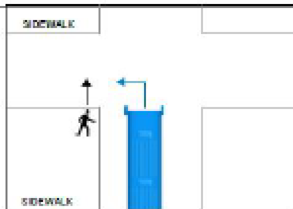
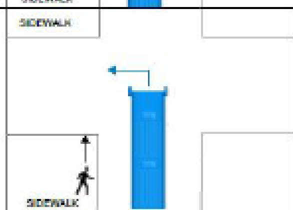
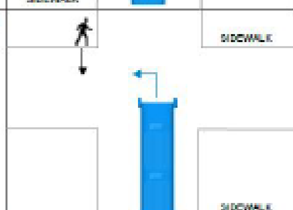
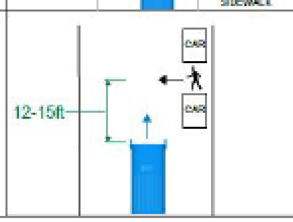




# Section 14 – Test Scenarios

| Scenario | Schematic | Kinematics | Description |
|---|---|---|---|
| #1 |   | | Determine whether the SHIELD+ system will warn the driver of a pedestrian traveling parallel to the curbside of the bus, in the same direction as the bus driving straight. For this scenario, the VRU is walking between 2 to 3 feet away from the bus body and there should not be any point of contact between the bus and the VRU. Only a **yellow** alert should be triggered on the **right** display |
| #2 |   | | Determine whether the SHIELD+ system will warn the driver of a pedestrian traveling parallel to the roadside of the bus, in the same direction as the bus driving straight. For this scenario, the VRU is walking between 2 to 3 feet away from the bus body and there should not be any point of contact between the bus and the VRU. Only a **yellow** alert should be triggered on the **left** display |
| #3 |   | | Determine whether the SHIELD+ system will warn the driver of a pedestrian traveling perpendicularly to the front of the bus, For this scenario, the VRU is alternating between 1 to 6 feet away from the bus body (on the curbside), and there should not be any point of contact between the bus and the VRU. Expect to receive **yellow and red** alerts from the **right** display |

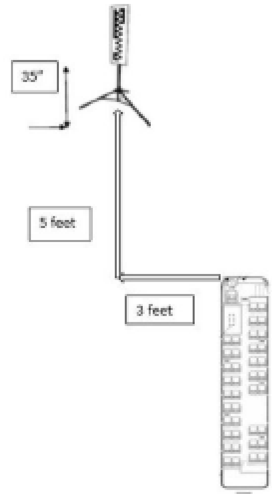
| | | | |
|---|---|---|---|
| #4 |   | | Determine whether the SHIELD+ system will warn the driver of a pedestrian traveling perpendicularly to the front of the bus, For this scenario, the VRU is alternating between 1 to 6 feet away from the bus body (on the roadside), and there should not be any point of contact between the bus and the VRU. Expect to receive **yellow and red** alerts from the **left** display |
| #5 |   | | Determine whether the SHIELD+ system will warn the driver of a pedestrian traveling in a path of a head on collision. For this scenario, the VRU is 10 to 15 feet away from the bus, and there should not be any point of contact between the bus and the VRU. Expect to receive **yellow and red** alerts from the **center** display |
| #6 |   | | Determine whether the SHIELD+ system will warn the driver of a pedestrian traveling in a path of a bus turning right. For this scenario, the VRU is aligned with the front wheel of the bus while the turn is executed, and there should not be any point of contact between the bus and the VRU. Expect to receive **yellow and red** alerts from the **right** display |
| #7 |   | | Determine whether the SHIELD+ system will warn the driver of a pedestrian traveling in a path of a bus turning right. For this scenario, the VRU is located near the middle door of the bus as the turn is executed, and there should not be any point of contact between the bus and the VRU. Expect to receive **yellow and red** alerts from the **right** display |

| | | | |
|---|---|---|---|
| #8 |   | | Determine whether the SHIELD+ system will warn the driver of a pedestrian traveling in a path of a bus turning left. For this scenario, the VRU is aligned with the front wheel of the bus as the turn is executed, and there should not be any point of contact between the bus and the VRU. Expect to receive **yellow and red** alerts from the **left** display |
| #9 |   | | Determine whether the SHIELD+ system will warn the driver of a pedestrian traveling in a path of a bus turning left. For this scenario, the VRU is located near the middle door of the bus as the turn is executed, and there should not be any point of contact between the bus and the VRU. Expect to receive **yellow and red** alerts from the **left** display |
| #10 |   | | Determine whether the SHIELD+ system will warn the driver of a pedestrian traveling in a path of a bus turning left. For this scenario, the VRU is expected to start crossing the street so that they enter the A-pillar blind spot of the driver, and there should not be any point of contact between the bus and the VRU. Expect to receive **yellow and red** alerts from the **left** display |
| #11 |   | | Determine whether the SHIELD+ system will warn the driver of a pedestrian entering the roadway perpendicular to the bus from between two parked cars. For this scenario, the VRU will enter the roadway from a distance of 12-15 ft away from the front of the bus, and there should not be any point of contact between the bus and the VRU. Expect to receive **red** alerts from **both** displays<br><br>Warning: This test is dangerous to perform. Please use caution when performing this scenario |

## Section 15 - Calibration

**Yaw alignment:**

1- Put the TAC, 3 feet to the Left from the Bus Left front corner, and 5 feet forward from the front of the bus (see image bellow)




## Height from the ground to lens (Total Height -4 In)

This table will define the Standard Alerts Configurations for Shield+:

| Alert Functions | Volume Level | Setting |
|---|---|---|
| UFCW | 3 | Virtual bumper w/bike rack 39" |
| | | Virtual bumper w/o bike rack 78" |
| LDW | | Disabled |
| HMW | 0 | Alert at 1.0 seconds |
| SLI | 0 | +10 mph |

**Yaw Alignment (continued)**

2- Open the ME Toolkit program and check the image.

3- Adjust the camera (Camera attachment to the windshield) so the Red Cross is in the middle of the TAC (Shown above).

**Horizon alignment:**

1- Measure the camera height and mark on the TAC the measured Camera height minus 4 inches.

*Figure 21: Camera angle adjustment*

2- Align the camera horizon by placing the Red Cross on the TAC marking. This process is a physical change in the camera angle that must be manually adjusted by adjusting the camera angle (by moving it up/down the Mobileye camera railing).

If for example the camera height is at 51 inches, we need to make a mark on the TAC at 47 inches and then need to align the Red Cross at 47 inches.

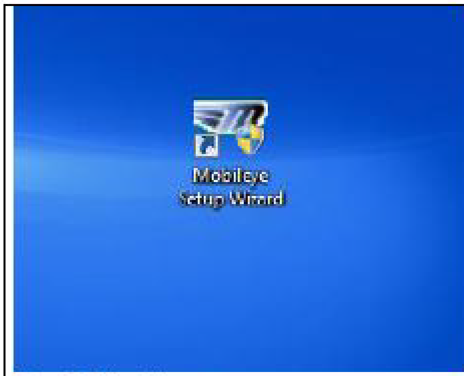
<table>
<tr>
<td>

Figure 39: Wizard shortcut</td>
<td>Click on the Mobileye SETUP WIZARD icon to open the application</td>
</tr>
<tr>
<td>

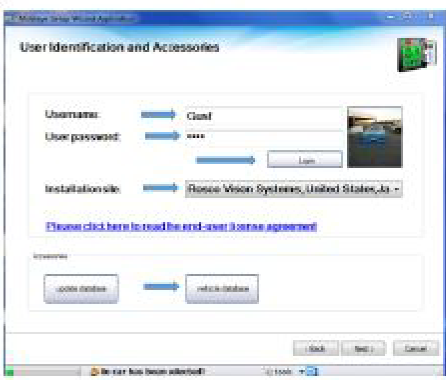
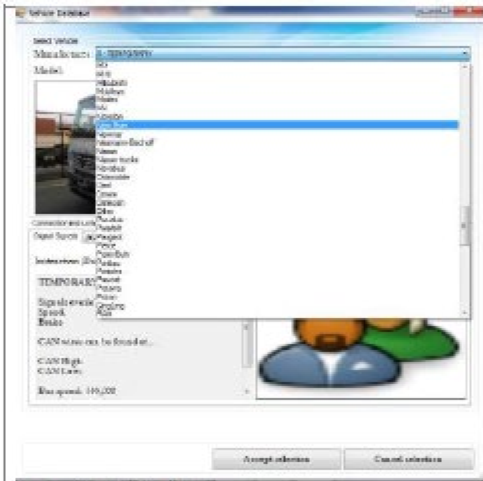
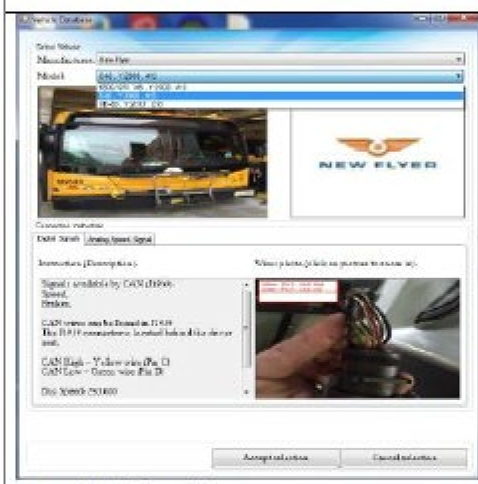
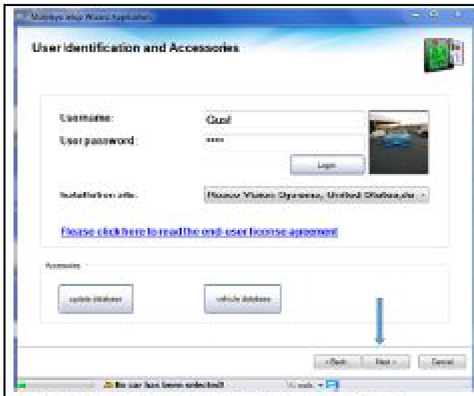
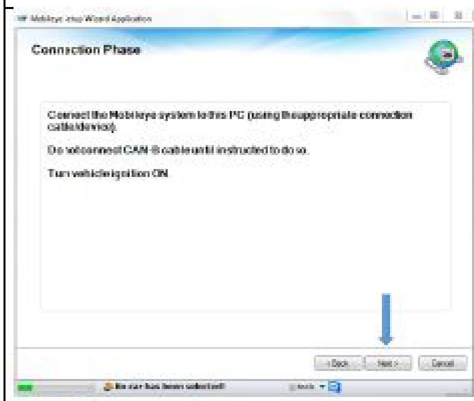
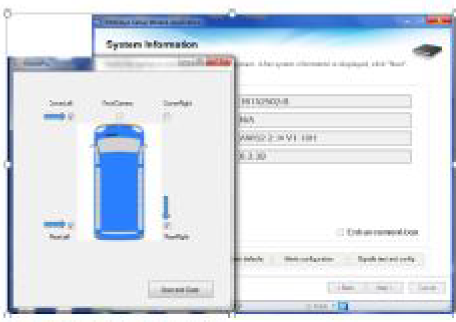
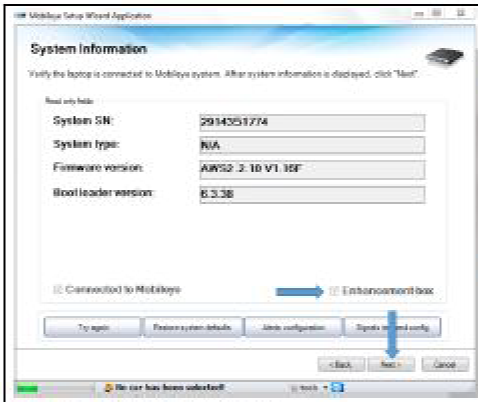
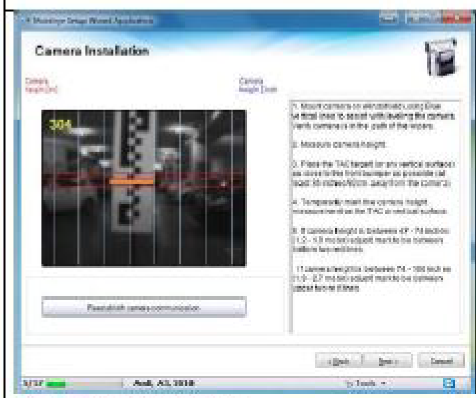
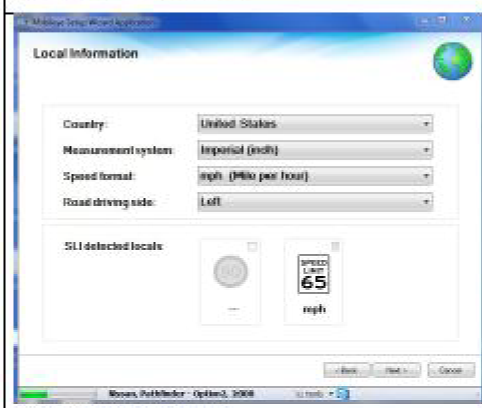
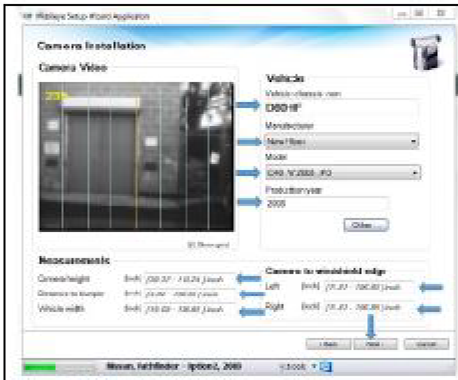
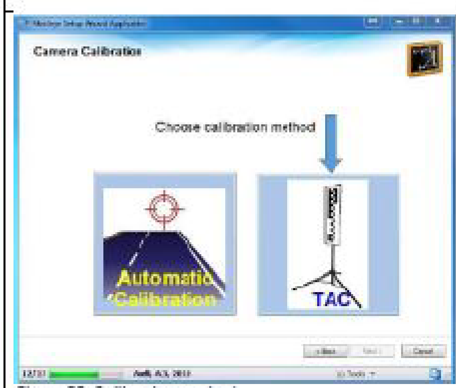
Figure 40: Wizard welcome page</td>
<td>Click Next to begin the installation</td>
</tr>
<tr>
<td>

Figure 41: User identification and accessories</td>
<td>1) Enter your Username & Password<br>2) click on “Login site”<br>3) Choose your installation site<br>4) Click on the Vehicle Database</td>
</tr>
</table>

| | |
|---|---|
| <br>*Figure 42: Vehicle database* | Choose your car manufacturer |
| <br>*Figure 43: Vehicle model* | 1) Choose the relevant car model<br><br>**Note 19:**<br>After choosing the car Manufacturer, you will get instructions where to find the CAN harnesses in the vehicle and what signals are available by CAN-bus<br>You will also get a picture describing the CAN-bus harnesses location<br><br>2) Accept the selection |

| | |
|---|---|
| <br>*Figure 44: User identification next page validation* | 1) After selecting the vehicle, you wanted, return to the Mobileye Setup Wizard, "User Identification &, Accessories" slide and continue the calibration process.<br>2) The selected vehicle will appear in all the following steps<br>3) Click on "Next" to continue |
| <br>*Figure 45: Connection phase* | 1) Connect your Laptop to the Mobileye system using the "EyeCAN" cable or "Kvaser" cable.<br>2) Connect E-box to Mobileye5 (if this is a Mobileye 5 analog installation).<br>3) Click on "Next" to initiate connection with the system |
| <br>*Figure 46: System information* | 1) Choose and select the cameras you will install with your system<br><br>Note: The master camera will automatically be selected. |

| | |
|---|---|
| Figure 47: Master camera version | 1) Please verify all relevant system information is shown.<br>**Note: 20**<br>When installing a Mobileye 5 system using the Mobileye E-box, make sure to:<br>Connect the Mobileye E-box to the Mobileye 5 system.<br>Confirm the E-box has been recognized (indicated by a V in the Enhancement–box check box).<br>2) Click "Next" to continue. |
| Figure 48: Camera installation | 1) Mount the master camera on windshield using blue vertical line to assist with leveling the camera.<br>2) Verify camera is in the path of the wipers and measure the camera height<br>3) Place the TAC target for any vertical surface as close to the front bumper as possible at least 36 inches away from the camera<br>4) Temporarily mark the camera height measurement on the TAC on vertical surface<br>5) Use the Red lines to properly attach the camera to the windshield while adjusting the angle.<br>6) verify it is not rotated or tilted. |
| Figure 49: Local information | 1) Select your "Country"<br>2) Select the "Measurement system"<br>3) Select the "Speed format"<br>**Note 21:**<br>Confirm "SLI detected locals" matches the speed sign type and the Speed unit (km/h or mph) of the selected Country<br>4) Click "Next" to continue |

<table>
<tr>
<td><br>Figure 50: Measurements</td>
<td>Fill in the necessary information:<br>1) "Vehicle Chassis Number"<br>2) "Manufacturer"<br>3) "Model"<br>4) "Production year"<br>5) "Camera Height"<br>6) "Distance to bumper"<br>7) "Vehicle width"<br>8) "Left"<br>9) "Right"<br>10) Click "Next" to continue<br>Car Information will show automatically if exist in vehicle Database. If vehicle details are not in Database, click on "Other" to add the vehicle details.</td>
</tr>
<tr>
<td><br>Figure 51: Signal source</td>
<td>1) If a vehicle was chosen using the: "Vehicle Database", it is possible to switch the signals source back to Analog (Only for C2 series or Mobileye 5 with E-box)<br><br>2) If all signals are available by Vehicle CAN-bus, there is no need to choose the Polarity (Option is disabled)<br><br>3) Click "Next" to continue</td>
</tr>
<tr>
<td><br>Figure 52: Calibration method</td>
<td>Now choose the preferred calibration method.<br><br>Always choose Automatic Calibration</td>
</tr>
</table>

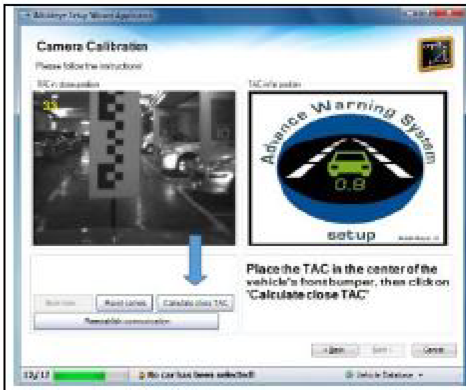



*Figure 53: Close TAC calculation*

Camera Calibration

1) Locate the "TAC Target" exactly in the middle of the vehicle's front bumper.

For cars –close as possible to the front bumper.

For trucks or buses –1 meter away from the front bumper

2) Click on "Calculate close TAC"


*Figure 54: Far TAC calculation*

1) Move the TAC Target to the Far position (1 meter away from the vehicle's front bumper)
2) Click on "Calculate far TAC"

After "Far TAC calculation" is completed, an image of the close target with red dots will appear

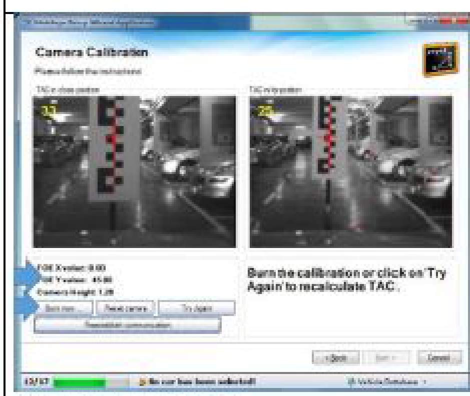
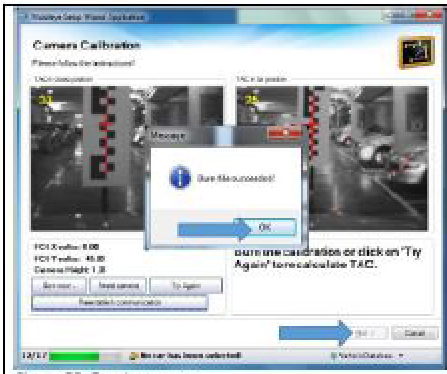
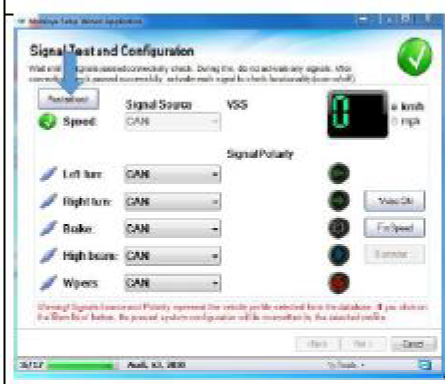
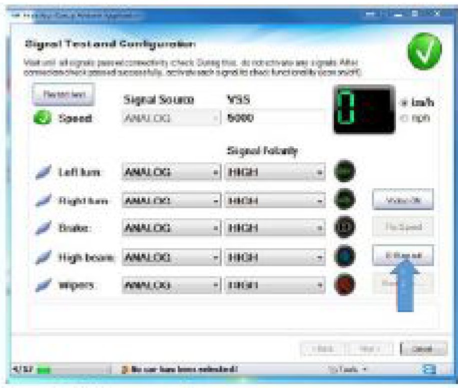
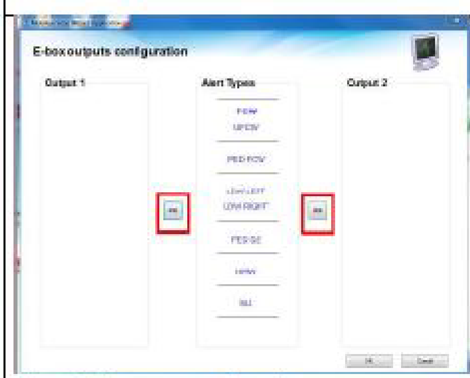
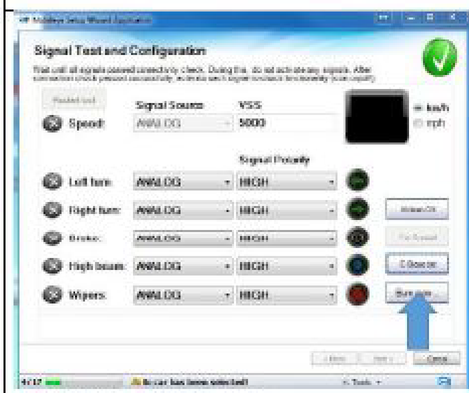
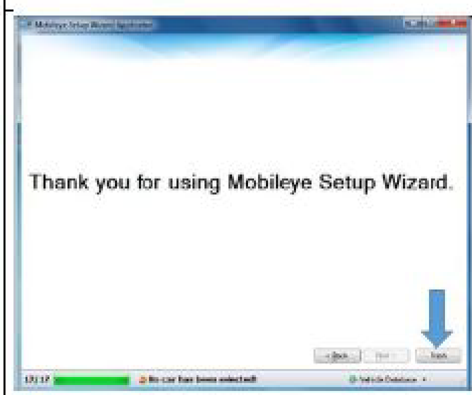



*Figure 55: Process verification*

1) After TAC calculation is complete, you can see the FOE and Camera height results.
2) Click on "Burn Now"
3) If calculation fails, click on "Try Again"

| | |
|---|---|
| <br><br>*Figure 56: Burning process* | 1) When the burning process is completed click "OK" in the pop up message<br>2) Click "Next" to continue |
| <br><br>*Figure 57: Alerts configuration* | The Alerts Configuration screen enables users to define the system settings (sensitivity values) and disable the system control buttons so drivers cannot modify the system settings.<br><br>when changing any value, you must burn the new configurations |
| <br><br>*Figure 58: Signal test and configuration* | Activate and verify each signal.<br> Signal is not detected by the system<br> Signal detected by the system, but not activated.<br> Signal detected and activated.<br> Signal is disabled.<br><br>If any signal fails during the activation test or connection verification, click Restart test to retest or activate the signal. |

| | |
|---|---|
|  Figure 59: Drive test | **Test drive:**<br>1) Drive and confirm speed indication in the Setup Wizard matches to the actual speed of the car.<br>2) After completing speed test, click on "Next" button to finish the wizard.<br>**Note 22:**<br>*If speed doesn't match the real vehicle speed, change the VSS rate, and click "Burn now" (this is optional only when the Speed Signal source is Analog).*<br>*Click "Video ON" if you want to see the camera image (low resolution)* |
|  Figure 60: Enhancement Box | Enhancement Box<br>When E-Box is connected a "E-Box out" button will appear.<br>Click on "E-Box out"<br>Enhancement Box features: additional independent configurable analog Outputs. |
|  Figure 61: E-box outputs configuration | Choose the alert type from the list and assign it to the relevant output by clicking Left or Right arrows.<br>Up to 3 Alert Types can be assigned to each output.<br>SLI Alert Type cannot be assigned with other Alert Types |

| | |
|---|---|
| <br>*Figure 62: Alert output type* | Choose Alert Output Type:<br>- Continuous<br>Output will be active for as long as the alert is active<br>- Patterned<br>Output can be configured according to user demands.<br>- If you choose Alert Output Type: "Patterned" Choose the output Duration Effective –Output will be active for as long as the Alert is active (On/Off)<br>- Choose to limit the Output duration by choosing any of the time options in the list<br>- Using the options, you can configure the output pattern duration (in milliseconds) |
| <br>*Figure 63: Signal burning process* | After E-Box configuration is complete press "Burn now" to burn the new outputs settings<br>Click "Next" to finish the installation<br><br>For turn signals choose High for positive switching signals, Low for negative switching signals |
| <br>*Figure 64: Wizard final step* | The calibration process is over<br>Please click on "Finish" to exit. |

# Section 16 – Adaptive LDW Width

To improve system performance (and decrease LDW nuisance) in certain driving scenarios (large/wide vehicles driving on narrow roads/lanes), Mobileye is introducing the "Adaptive LDW Width".
This new feature will automatically adjust the system LDW sensitivity depending on the Lane Width and Vehicle Width to disable or lower the LDW feature sensitivity when driving on relatively narrow roads.

## 16.1 - Lane Width standards

The U.S. Interstate Highway System uses a 12-foot (3.7 m) standard for lane width. 11-foot (3.4 m) lanes are found to be acceptable by the Federal Highway Administration
9-foot (2.7 m) lanes are found in some areas.

Ranges for Lane Width

| Type of Roadway | Rural | | Urban | |
|---|---|---|---|---|
| | US (feet) | Metric (meters) | US (feet) | Metric (meters) |
| Freeway | 12 | 3.6 | 12 | 3.6 |
| Ramps (1-lane) | 12-30 | 3.6-9.2 | 12-30 | 3.6-9.2 |
| Arterial | 11-12 | 3.3-3.6 | 10-12 | 3.0-3.6 |
| Collector | 10-12 | 3.0-3.6 | 10-12 | 3.0-3.6 |
| Local | 9-12 | 2.7-3.6 | 9-12 | 2.7-3.6 |

(Source: A Policy on Geometric Design of Highways and Streets, AASHTO)

In Europe road width varies per country, with the minimum width of lanes being anywhere between 2.5 to 3.25 meters (8.2 to 10.7 ft.) (Thus comparable to US lanes).

## 16.2 - Mobileye Lane Detection

The Mobileye system continually measures the Lanes Width.
Mobileye Lane Width measurement must detect both lane markings in order to be operational.
If only a single lane marking is detected, normal LDW operation will continue.

## 16.3 - Adaptive LDW Width

Below are the 3 new factors which will affect the Mobileye LDW feature in different road scenarios.
The Mobileye Adaptive LDW Width is a result of extensive R&D taking into account standard Lane and Vehicle Widths around the world.

The Adaptive LDW Width **requires no configuration** from the installer or from the user.
Adaptive LDW Width is depended on the LDW sensitivity setting level.

If LDW sensitivity setting is set to level "0" – No LDW

If LDW sensitivity setting is set to level "1" or "2" – the LDW alert will function normally with additional Adaptive LDW Width feature described below.

### 16.3.1 – Narrow Lane

If the Lane Width is smaller than the Vehicle Width (front wheelbase) + 15%, then the LDW will be automatically **disabled** (until the lane width increases to normal values).

### 16.3.2 - Acceptable Lane

If the Lane Width is greater than the Vehicle Width (front wheelbase) +15%, but smaller than the Vehicle Width (front wheelbase) +30%, then LDW alert will be **late** (meaning LDW alert will sound after the lane crossing).

### 16.3.3 - Standard Lane

If the Lane Width is greater than the Vehicle Width (front wheelbase) +30%, then the LDW feature will function **normally** (see Mobileye User Manuals LDW sensitivity sections).

## 16.4 – LDW Examples

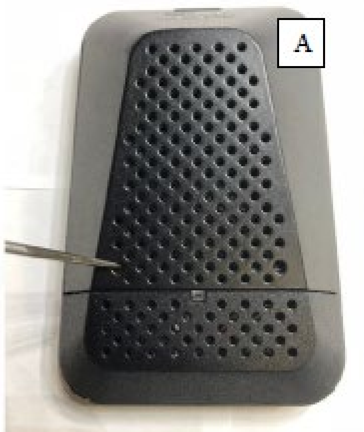
*Example 1:*
A truck with width (front wheelbase) of 2.8 meters (9.18 ft.):
1. If the Lane Width is smaller than the 3.22m (10.56 ft.) then LDW will automatically turn off (temporarily)
2. If the Lane Width is greater than the 3.64m (11.94 ft.) then LDW will function normally.
3. If the Lane Width is between 3.22m (10.56 ft.) and the 3.64m (11.94 ft.), for our example the Lane Width is 3.4m (11.15 ft.), then LDW will function 12cm (4.72 inch) after the wheel crossed the lane marking (late LDW alert) .

*Example 2:*
A passenger Vehicle with Width (front wheelbase) of 2.0 meters (6.56 ft.):
1. If the Lane Width is smaller than the 2.3 (7.54 ft.) then LDW will automatically turn off (temporarily)
2. If the Lane Width is greater than the 2.6 (8.53 ft.) then LDW will function normally.
3. If the Lane Width is between 2.3m (7.54 ft.) and the 2.6 (8.53 ft.), for our example the Lane Width is 2.4m (7.87 ft.), then LDW will function 10cm (7.87 inch) after the wheel crossed the lane marking (late LDW alert) .

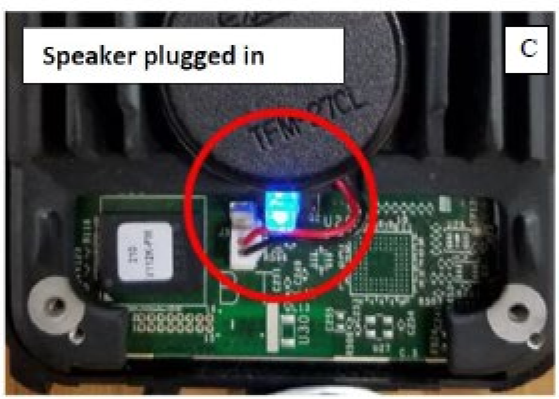
## Section 17 – Stealth Mode

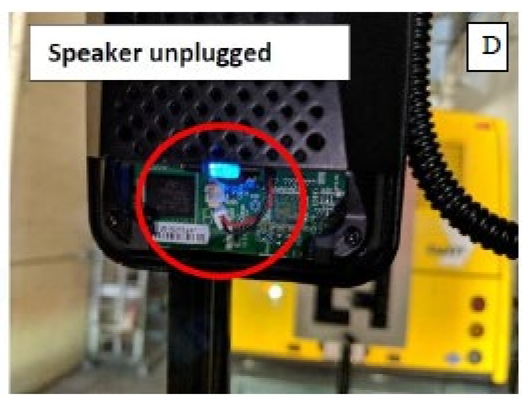
### 17.1 – Turning off Front Sensor Audible Alerts

- Remove the cover from the Front sensor by pushing in the tabs as shown below (Photo A)
- Remove the lower cover (Photo B)
- Unplug the 2-pin white connector from the circuit board (Photo C)
- When the plug is disconnected (Photo D) cover the LED with tape if it's going to be a distraction to the driver







## 17.2 - Turning off Front Visual Alerts


The Shield+ System is put in stealth mode after the install is complete to turn off driver displays & alerts

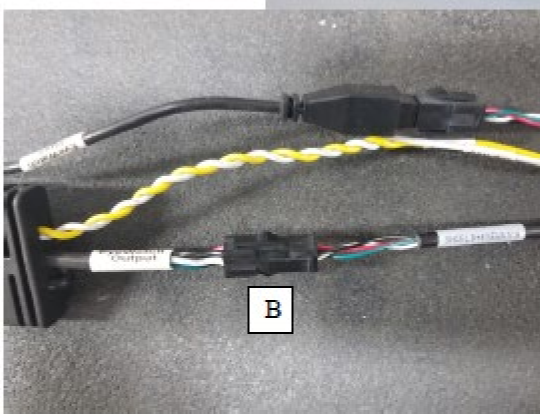
To Put the system in stealth mode:

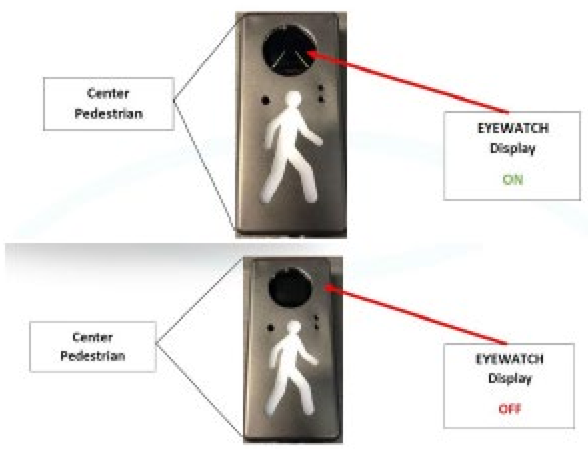
- Locate the Junction box (Photo A)
- Remove the plugs in the I/O Port-A & Output Port-B (Photo B)

Reverse procedures to take the system out of Stealth Mode

## 17.3 – Turning off Eyewatch Alert Display

- Locate the CAN Sensor Harness (Photo A)
- Disconnect the Eyewatch Out plug (Photo B) from the CAN sensor harness

## Section 18

## Approvals, Revisions & Release Dates

**Prepared By:**
**Christopher Consalvo, Technical Trainer for Rosco Vision Systems**

# Appendix D – Photo Catalog of Mobileye Shield+ Installation

**Figure D-1 – Placement of master sensor**

**Figure D-2 – Curbside rear sensor placement**

**Figure D-3 – Left pedestrian display placement**

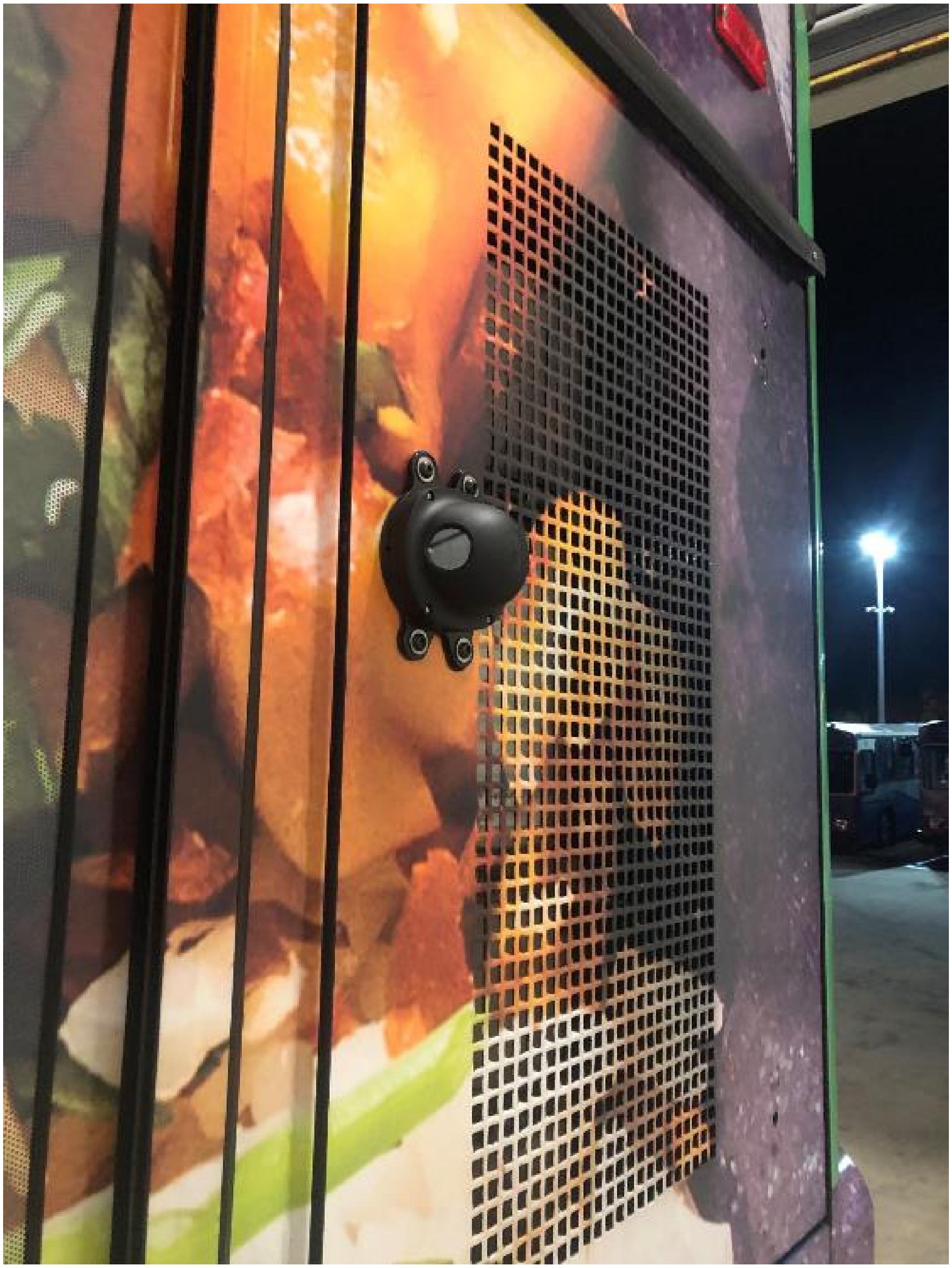


**Figure D-4 – Street-side rear sensor placement**

**Figure D-5 – Right side pedestrian display placement**

**Figure D-6 – Curbside rear sensor routing**


**Figure D-7 – Junction box under shelf**

**Figure D-8 – Left corner sensor placement**

**Figure D-9 – Master sensor and creator display**


**Figure D-10 – Midpoint box**

**Figure D-11 – Roadside rear sensor harness routing**

# Appendix E – Executed Agreement between UF and Rosco Trucking LLC

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ROSCO® COLLISION AVOIDANCE

OFFICIAL MOBILEYE PARTNER

AUTOMOTIVE VISION SAFETY SOLUTIONS

Collision Avoidance Systems

July 25, 2018; Revised September 13, 2018 General Terms and Conditions item 9. (c) (i); Revised 12/3/2018 to extend proposal another 90 days

University of Florida Transportation Institute (UFTI)
Clark Letter, Ph.D.
515 Weil Hall
PO Box 116580
Gainesville, FL 32611

**Re: Proposal for Mobileye Shield+ System implementation with ten (10) City of Gainesville RTS 40' Gillig buses**

**<u>Product Description</u>**

Mobileye Shield+ System part number VQS4660 is a collision avoidance system for buses and trucks. The system consists of four (4) Mobileye Model 630 smart vision sensors, two (2) exterior sensor housings, and three (3) interior driver displays. The center driver display contains the Mobileye Eyewatch driver display.

The System Includes:

- Front and side sensing of pedestrians and cyclists in complex urban environments including turns and intersections, with outputs to the bus driver that will provide earlier detection of potential collisions with these threats in time to stop the bus.

- Forward facing vehicle functions such as urban and highway forward collision warning (UFCW & FCW), lane departure warning (LDW), headway following time monitoring and warning (HMW), pedestrian and cyclist detection (PDZ & PCW), and speed limit indication (SLI), all visible and audible through the Mobileye Eyewatch display.

- Three (3) driver displays which visually and audibly alert the driver of potential collisions with pedestrian or cyclists.

- Shield+ Telematics mapping of Mobileye Shield+ sensor messages for route evaluation of activity and conditions. One year service subscription included. Rosco will provide Shield+ Telematics training to designated Customer personnel with access to data and ability to create reports.

90-21 144th Place, Jamaica, NY 11435 Tel: (800) 227-2095 Fax: (718) 297-0323

www.roscoca.com

**Installation**

Rosco will install ten (10) Gillig buses of model year 2008 or newer at one location. Customer will provide a dedicated driver available for testing when installations are completed. This coordination will be done on site between the contracted installer and Customer contact. Rosco will work with Gainesville RTS to help train drivers and maintenance technicians on all functions. The buses will be placed in 'stealth mode' (all displays inactive) for the first four (4) weeks to obtain a baseline of operator behavior without the feedback from the system. The implementation period will last for at least eight to twelve (8 to 12) weeks after 'stealth mode' for integration of Shield+ into transit operations. Rosco will conduct data review conference calls on status of the system and telematics relayed data on an agreed upon schedule.

**Price**

The installation is $2,000 per bus and system hardware is $6,550 per bus for a minimum of ten (10) 40' Gillig rigid buses. Total installed cost is $8,550 per bus. The cost of Shield+ Telematics after the first year is $25 per bus per month and shall be paid for by Gainesville Regional Transit.

**Limited Use License**

1. Rosco and Mobileye hereby grant the original purchaser of the VQS4660 ("Buyer"), a non-exclusive and non-transferable license to use the software embedded in the VQS4660 as supplied by Mobileye, as well as the documentation accompanying the VQS4660.

2. Buyer shall not: (a) modify, adapt, alter, translate, or create derivative works from any software or hardware residing in or provided by Rosco and Mobileye in conjunction with the VQS4660, (b) reverse assemble, decompile, disassemble, or otherwise attempt to derive the source code for such software without written authorization from Mobileye, or (c) assign, sublicense, lease, rent, loan, transfer, disclose, or otherwise make available such software.

**Terms & Conditions**

1. All systems and the information provided by Rosco and Mobileye are proprietary and confidential intellectual property.
2. Delivery 3 to 4 weeks after order acceptance.
3. Freight, duties, and all other applicable charges will be added.

4. Terms of Payment – Net 30 days.
5. All prices are exclusive of taxes.
6. Rosco Limited Warranty.
7. Proposal good for 90 days.

**IMPORTANT CUSTOMER INSTRUCTIONS AND INFORMATION**

**CUSTOMER AND ALL DRIVERS AND MECHANICS MUST READ THE USER MANUAL AND THE IMPORTANT SAFETY INSTRUCTIONS AND WARNINGS BELOW CAREFULLY BEFORE INSTALLING OR USING THE SHIELD+ WARNING SYSTEM ("VQS4660") ™**

**By Installing the VQS4660 Driver Assistance System, you will be acknowledging and agreeing to operate the VQS4660 in accordance with the Safety Instructions, Warnings and the General Terms and Conditions set forth below.**

**SAFETY INSTRUCTIONS**

The VQS4660 system should not be transferred between vehicles, other than by an authorized VQS4660 Dealer or Installer or a Rosco-certified employee of Customer, including its subsidiaries.

The VQS4660 should only be operated with 12VDC ~24VDC power.

Do not cover or obstruct the sensors or the VQS4660 display units.

Do not use the VQS4660 system for any purpose other than as described in the User Manual.

**WARNINGS**

A) THE VQS4660 IS A DRIVER ASSISTANCE SYSTEM WHICH IS INTENDED TO ALERT DRIVERS OF CERTAIN POTENTIALLY DANGEROUS SITUATIONS. THE VQS4660 IS DESIGNED TO REDUCE, BUT NOT ELIMINATE, CERTAIN RISKS OF LOSS. IT DOES NOT REPLACE ANY FUNCTIONS DRIVERS WOULD ORDINARILY PERFORM IN OPERATING A MOTOR VEHICLE, NOR DOES IT DECREASE THE NEED FOR DRIVERS TO STAY VIGILANT AND ALERT IN ALL OPERATING CONDITIONS, TO CONFORM TO ALL SAFE OPERATING STANDARDS AND PRACTICES, AND TO OBEY ALL TRAFFIC

RULES AND REGULATIONS.

B) THE VQS4660 IS NOT DESIGNED TO WORK IN LOW LIGHT, OR DARKNESS FOR PEDESTRIAN AND CYCLIST DETECTION. THE VQS4660 DETECTS VEHICLES IN DAY AND NIGHT OPERATIONS FROM THE MASTER CAMERA ONLY. IN ADDITION, WEATHER, LIGHT CONDITIONS, SIDEWALK OBSTRUCTIONS, BUS SHELTERS AND OTHER FIELD CONDITIONS CAN ADVERSELY AFFECT THE VQS4660 SYSTEM'S RECOGNITION AND RESPONSE CAPABILITIES. IT CANNOT AND DOES NOT GUARANTEE 100% ACCURACY IN THE DETECTION OF PEDESTRIANS, CYCLISTS, VEHICLES OR OPERATING LANES, NOR IN PROVIDING WARNINGS OF ALL POTENTIAL ROAD HAZARDS. ACCORDINGLY, DRIVERS SHOULD NOT RELY ON THE VQS4660 TO ASSURE THEIR OPERATING SAFETY, BUT RATHER SHOULD CONTINUE TO RELY ON SAFE OPERATING PRACTICES.

C) THE VQS4660 IS NOT AN AUTOMATED OPERATING SYSTEM AND IT DOES NOT ACT AS A SUBSTITUTE FOR ANY ASPECT OF DRIVER VEHICLE CONTROL OR SAFE OPERATING PRACTICES. DRIVERS ARE STRONGLY CAUTIONED NOT TO RELY ON THE VQS4660 AS A REPLACEMENT, TO EVEN THE SLIGHTEST DEGREE, FOR EXERCISING ALL DUE CAUTION IN ASSURING THAT THEY ARE OPERATING SAFELY AND AVOIDING ACCIDENTS. ANY FORM OF AUTOMATED TESTING (INCLUDING ANY FORM OF DECELERATION) UTILIZING SHIELD+ OUTPUTS CAN NOT BE CONDUCTED WITHOUT WRITTEN AUTHORIZATION FROM MOBILEYE.

D) DRIVERS SHOULD EXERCISE CAUTION IN USING THE VQS4660 DISPLAY UNIT AND ALWAYS MAINTAIN FULL CONCENTRATION ON THE ROAD AT ALL TIMES, INCLUDING WHILE LOOKING AT THE VQS4660 DISPLAYS.

E) VEHICLES WITH BICYCLE RACKS MOUNTED TO THE FRONT MAY EXPERIENCE FORWARD VISION OBSTRUCTIONS. RAISING FORWARD VISION SENSOR TO AVOID OBSTRUCTIONS MAY COMPROMISE SYSTEM PERFORMANCE. CUSTOMER ACCEPTS RESPONSIBILITY FOR ANY OBSTRUCTIONS OR REDUCTION IN

PERFORMANCE DUE TO BICYCLE RACKS.

## GENERAL TERMS AND CONDITIONS

1. Rosco does not represent or warrant that the system may not be compromised or circumvented or that the system will prevent injury, loss of life, or property damage, or that the system will in all cases provide the protection for which it is intended.

2. Customer understands and agrees that Rosco is not an insurer and that insurance covering personal injury, including death, and real or personal property loss or damage shall be obtained and maintained by the Customer.

3. Notwithstanding anything to the contrary, Rosco agrees to indemnify and defend Customer against any claim for personal injury, death or property damage arising out of a collision with a pedestrian, cyclist, passenger or vehicle to the extent that such collision was solely caused by the negligence or willful conduct of Rosco.

4. Customer agrees that Rosco does not make any implied warranties of fitness for a particular purpose or any other implied warranty.

5. Customer assumes any and all risks of personal injury and property damage attributable to the negligent acts or omissions of the Customer and its officers, employees, servants, and agents while acting within the scope of their employment by Customer. Customer, as a public body corporate, warrants and represents that it is self-funded for liability insurance, with said protection being applicable to officers, employees, servants, and agents while acting within the scope of their employment by Customer. Customer and Rosco further agree that nothing contained herein shall be construed or interpreted as (1) denying to either party any remedy or defense available to such party under the laws of the State of Florida; (2) the consent of the Customer or the State of Florida or their agents and agencies to be sued; or (3) a waiver of sovereign immunity of the Customer or of the State of Florida beyond the waiver provided in section 768.28 Florida Statutes, however, Rosco does not hereby assume any of Customer's liability in excess of the limitation in section 768.58 Florida Statutes.

6. Rosco's liability under this agreement shall not under any circumstances exceed the amounts payable under insurance policies maintained by Rosco. In no event shall Rosco be liable for any special, collateral, indirect, punitive, incidental, consequential, or exemplary damages in connection with or arising out of the use of the VQS4660 system.

7. This agreement shall be governed by the substantive law of the State of Florida without giving effect to any part of such law that would result in the selection or application of the law of any other jurisdiction. Customer hereby irrevocably consents to the exclusive jurisdiction in the courts of the United States District Court for the Northern District of Florida or the state courts for Alachua County, Florida.

8. This agreement may be executed in counterparts all of which shall be deemed to be the same agreement. This agreement may be executed by facsimile signatures transmitted by .pdf and all such signatures will be deemed original signatures for all purposes.

9. TELEMATICS AND DATA

If the Product Schedule includes Telematics Data and Equipment, then this shall be applicable.

(a) Mobileye and Rosco may be collecting and processing certain data ("Data"), either directly or through third party devices for the purpose of identifying and mapping risk factors relating to drivers, areas, roads and similar elements and for identifying road and environmental conditions, mapping and localization solutions. These Data may include (i) **Alert Data**, meaning the type, time and number of alerts and geo-location information of alerts, (ii) **Road and Environmental Data**, meaning data related to the road, road conditions or environmental conditions, information on traffic lights, road signs, lanes, columns, streetlights, and signage (for identification, warning, direction, etc.), (iii) **vehicle** information such as vehicle identification number (VIN), make, model, and model year, or license plate number that identifies the hosting vehicle of the Product, (iv) **Performance Data**, such as precise location of vehicles, and routes traveled, and (v) other personally identifiable information.

(b) All Data collected will be owned by Mobileye and Mobileye will retain all right, title, and interest in the Data. Mobileye shall own all information, know-how, hardware, software and other technology created therefrom or associated with Mobileye's products and technologies, and any and all intellectual property and other proprietary rights relating thereto. Customer waives all rights, remedies and claims against Mobileye and Rosco, including claims for royalties or other compensation from any enhancements or new products developed from the Data. Mobileye shall be a third party beneficiary of this Agreement and shall have the right to enforce this Section.

(c) Mobileye hereby grants the Customer a non-exclusive, non-sublicenseable and non-transferable license to collect and store Data in the Customer's computer systems for the express and limited purposes set forth in this Section. In connection therewith and as a condition for the continued right to such License:

(i) Customer shall use all Data for the purpose of academic research and analysis and other related non-commercial purposes that intended to improve transportation safety for operators, pedestrians, passengers and other VRU's. Customer shall also have the right to use the Data for preparing academic and research publications, findings and conclusions, and may share Data with any partners that may be participating in a research project provided such partners are also bound by these terms. Customer shall not sell, give, license, sublicense, transfer or share (irrespective of how denominated) the Data, or use the Data for any commercial purpose, by itself or in conjunction with any third-party who may seek to commercialize the Data or reverse engineer the System.

(ii) Customer shall use all reasonable legal, organizational, physical, administrative and technical measures and security procedures to safeguard and ensure the security of the Data and to protect the Data from unauthorized access, disclosure, duplication, use, modification or loss.

(d) Customer's license to use the Data shall expire on the date set forth in the Product Schedule, or if no date is set forth, the license shall expire one (1) year following the date of this Agreement.

## CUSTOMER CERTIFICATIONS

Customer hereby acknowledges that it has read and understood the Safety Instructions, Operating Manual, Warnings, General Terms and Conditions and Telematics and Data before installing or using the VQS4660 System.

| Rosco Collision Avoidance Inc. | University of Florida Transportation Institute |
|---|---|
| By: [signature] 12/3/2018 | By: Rob Luetjen |
| Name: Mike Cacic | Name: Rob Luetjen |
| Title: Program Manager | Title: Procurement Agent III |

ROSCO LIMITED WARRANTY

We warrant that all ROSCO mirror, camera, sun visor, and electronic vision products are free from defects in workmanship and materials for a period of ONE (1) YEAR from the date of receipt of the product. During the warranty period, we agree to provide a replacement for (or at our option repair) any ROSCO product and/or any one or more component parts of a ROSCO product, which malfunctions under normal use and service.

Upon discovering a defect, the customer must contact ROSCO for a return authorization and then must return the product, and/or component part, together with proof of date of receipt of the product, to ROSCO INC. 144-31 91 Ave. Jamaica, New York 11435. The customer and not ROSCO will be responsible for the payment of all removal, installation and transportation charges for return of defective products or components to ROSCO. Transportation charges for such return must be prepaid. The repaired or replaced equipment will be returned to the customer with transportation charges prepaid by ROSCO. Replacement (or repaired) products and/or component parts are warranted only for the unexpired term of the original warranty.

This warranty does not cover defects caused by neglect, misuse, incorrect application, incorrect installation, water damage, vehicle wash facilities, alteration or repair in any manner outside ROSCO's factory, or damage caused by the return shipment due to inadequate packaging or mishandling. If the alleged defect is due to any of these causes, the customer will be advised of the findings and asked what action is to be taken. If ROSCO is requested to repair the product, a repair charge estimate will be prepared and the customer's written permission (purchase order, repair, etc.) will be necessary to proceed with the repair of the product and/or component part. Transportation charges for such returns will be the responsibility of the customer.

This warranty may not be expanded by oral representation, written sales information, drawings or otherwise. Repair or replacement is the exclusive remedy for defective products under this warranty. This warranty is expressly in lieu of all other warranties, including any implied warranty of merchantability or any implied warranty of fitness for a particular purpose on any ROSCO product. ROSCO shall not be liable for any consequential or incidental damages for breach of any express or implied warranty on any ROSCO product.

WARRANTY DISCLAIMER

This Limited Warranty is the sole and exclusive warranty applicable to the Rosco VQS4660 system. Rosco disclaims all other express warranties and all implied warranties of merchantability and fitness for a particular purpose, to the fullest extent permitted by applicable law. No representative, distributor, dealer or agent of Rosco has the authority to make any representation, warranty, or agreement on behalf of Rosco or Mobileye with respect to the Rosco VQS4660. No warranty of any kind or nature is made by Rosco beyond those expressly stated herein. In no event shall Rosco be liable for any special, collateral, indirect, punitive, incidental, consequential, or exemplary damages in connection with or arising out of the use of the Rosco VQS4660 system.

# Appendix F – Executed Memorandum of Understanding between UF and the City of Gainesville

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**Agreement between**

**University of Florida Board of Trustees**

**and**

**Gainesville Regional Transit System**

For Smart Testbed

**THIS AGREEMENT** ("Agreement") is made by and between the University of Florida Board of Trustees, a corporate body public of the state of Florida, (hereafter referred to as "UF"), whose address is UF Division of Sponsored Programs, 207 Grinter Hall, Box 115500, Gainesville, FL 32611-5500 and City of Gainesville d/b/a Gainesville Regional Transit System (hereafter referred to as "RTS"), whose address is 34 SE 13th Rd, Gainesville, FL 32601, each one a "Party" and collectively "Parties."

**WHEREAS, RTS** desires to collaborate with UF on research (the "Collaboration"), upon the terms and conditions hereinafter set forth; and

**WHEREAS**, the scope of the Collaboration includes UF contracting with Rosco Collision Avoidance, Inc. ("Rosco") for the purchase of ten (10) Mobileye Technologies ("Mobileye") Shield+ Systems ("System(s)") and implementation of the Systems within ten (10) City of Gainesville RTS 40' Gillig buses;

**NOW THEREFORE,** in consideration of the mutual covenants and agreements contained herein, RTS and UF agree as follows:

1. **Collaboration Terms:** The Parties agree to work together, using their best efforts to accomplish the goals of this Collaboration. UF will contribute equipment, RTS will contribute data, tools and/or services as specifically outlined in "**Exhibit A Collaboration Terms,**" which is attached to this Agreement and incorporated herein.

2. **Period of Performance:** The period of performance for this Agreement will begin on the date that this Agreement is signed by both Parties and will terminate on February 28th, 2020.

3. **Confidential Information**:

(a) "Confidential Information" means any confidential or proprietary information furnished by one Party ("Disclosing Party") to the other ("Receiving Party") in connection with the Collaboration that is specifically marked as confidential or followed up in writing to document its confidentiality as soon as possible but no more than fifteen (15) days after disclosure.

(b) For three (3) years after disclosure of Confidential Information, the receiving Party may only disclose Confidential Information to its directors, officers, employees, consultants, and contractors who are obligated to maintain its confidentiality and who need to know Confidential Information for the performance of the Collaboration. UF may refuse to accept any Confidential Information offered by RTS.

(c) The obligations of this Section do not apply to information that the Receiving Party can demonstrate (i) is publicly available; (ii) is independently known, developed, or discovered without use of Confidential Information; (iii) is made available by a third party without a known obligation of confidentiality to the disclosing Party; (iv) is required to be disclosed to comply with a law, regulation, or court or administrative order provided that the receiving Party uses reasonable efforts to provide prior written notice of the disclosure.

(d) The Disclosing Party (or a third party entrusting its information to the Disclosing Party) owns its Confidential Information. Upon expiration or termination of this Agreement or at the request of the Disclosing Party, the Receiving Party shall return all originals, copies, and summaries of Confidential Information in its possession or control, except that the Receiving Party may retain one (1) copy of the Confidential Information for the purpose of monitoring its obligations under this Agreement and such additional copies of or any computer records or files containing such Confidential Information that have been created solely by the Receiving Party's automatic archiving and back-up procedures, to the extent created and retained in a manner consistent with the Receiving Party's standard archiving and back-up procedures, but not for any other use or purpose.

4. **Data Ownership and Use:**

(a) "Background Data" means any facts and statistics collected for reference or analysis which are owned or controlled by a Party as of the Effective Date or conceived outside of the Collaboration.

(b) "Generated Data" means any facts and statistics collected independently by UF or RTS for reference or analysis as a result of this Collaboration. Generated Data does not include Rosco Mobileye Data as defined below.

(c) "Rosco Mobileye Data "means data collected by Rosco and/or Mobileye through the Systems that is shared with UF and/or RTS for the purpose of identifying and mapping risk factors relating to drivers, areas, roads and similar elements and for identifying road and environmental conditions, mapping and localized solutions. Rosco Mobiley Data may include (i) type, time and number of alerts and geo-location information of alerts, (ii) road, road conditions or environmental conditions, information on traffic lights, road signs, lanes, columns, streetlights, and signage (for identification, warning, direction, etc.), (iii) vehicle information such as vehicle identification number (VIN), make, model, and model year, or license plate number that identifies the hosting vehicle of the Product, (iv) location of vehicles, and routes traveled, and (v) other personally identifiable information.

(d) The Parties agree to joint ownership of any Generated Data. Each Party shall have full rights to use any Generated Data for any lawful purpose, including but not limited to, the right to analyze, improve internal operations and safety of RTS' busses and transit system, publish and share the Generated Data with a third party, and otherwise use Generated Data in a manner consistent with this Collaboration.

(e) By virtue of the contract between UF and Rosco, Rosco Mobileye Data will be owned by Mobileye and Mobileye will retain all right, title, and interest in the Data. Per the contract between UF and Rosco, UF and RTS may use Rosco Mobileye Data for the purpose of academic research and analysis and other related non-commercial purposes that intended to improve transportation safety for operators, pedestrians, passengers and other vulnerable road users. UF and RTS shall also have the right to use the Rosco Mobileye Data for preparing academic and research publications, findings and conclusions, and may share Rosco Mobileye Data with any partners that may be participating in a research project provided such partners are also bound by these terms. UF and RTS shall not sell, give, license, sublicense, transfer or share (irrespective of how denominated) the Rosco Mobileye Data, or use Rosco Mobileye for any commercial purpose, by itself or in conjunction with any third-party who may seek to commercialize the Rosco Mobileye Data or reverse engineer the System.

(f) The Parties agree that each will provide the Background Data which is specifically described in **Exhibit A Collaboration Terms** to the other Party.

(g) The Party providing the Background Data shall be the "Provider" and the Party receiving the Background Data shall be the "Recipient."

(h) Provider shall retain ownership of any rights it may have in the Background Data, and Recipient does not obtain any rights in the Background Data other than as set forth herein.

(i) Recipient shall not use the Background Data except as authorized under this Agreement. The Background Data will be used solely to conduct the Collaboration and solely by Recipient's authorized personnel or agents ("Recipient Personnel") that have a need to use, or provide a service in respect of, the Background Data in connection with the Collaboration and whose obligations of use are consistent with the terms of this Agreement (collectively, "Authorized Persons").

(j) Except as authorized under this Agreement or otherwise required by law, Recipient agrees to retain control over the Background Data and shall not disclose, release, sell, rent, lease, loan, or otherwise grant access to the Background Data to any third party, except Authorized Persons, without the prior written consent of Provider. Recipient agrees to establish appropriate administrative, technical, and physical safeguards to prevent unauthorized use of or access to the Background Data and comply with any other special requirements relating to safeguarding of the Background Data.

(k) Recipient agrees to use the Background Data in compliance with all applicable laws, rules, and regulations, as well as all professional standards applicable to such research.

(l) Except as provided below or prohibited by law, any Background Data delivered pursuant to this Agreement is understood to be provided "AS IS." PROVIDER MAKES NO REPRESENTATIONS AND EXTENDS NO WARRANTIES OF ANY KIND, EITHER EXPRESS OR IMPLIED. THERE ARE NO EXPRESS OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, OR THAT THE USE OF THE BACKGROUND DATA WILL NOT INFRINGE ANY PATENT, COPYRIGHT, TRADEMARK, OR OTHER PROPRIETARY RIGHTS. Notwithstanding, Provider, to the best of its knowledge and belief, has the right and authority to provide the Background Data to Recipient for use in the Project.

(m) Except to the extent prohibited by law, the Recipient assumes all liability for damages which may arise from its use, storage, disclosure, or disposal of the Background Data. The Provider will not be liable to the Recipient for any loss, claim, or demand made by the Recipient, or made against the Recipient by any other party, due to or arising from the use of the Background Data by the Recipient, except to the extent permitted by law when caused by the gross negligence or willful misconduct of the Provider. No indemnification for any loss, claim, damage, or liability is intended or provided by either Party under this Agreement.

5. **Publications:**

(a) RTS recognizes that UF Investigators must have the ability to publish findings, results or other information gained in the course of the Collaboration in scholarly journals, student dissertations, or other professional forums.

(b) In order to give the RTS an opportunity to review and advise regarding loss of intellectual property rights and/or to identify any inadvertent disclosure of RTS Confidential Information or Background Data, UF will submit to RTS copies of any proposed publication or presentation material involving the results of the Collaboration at least thirty (30) days in advance of the submission date for publication or planned presentation date.

(c) RTS recognizes that time is of the essence and the review of such materials shall be completed within thirty (30) days from the receipt of the planned publication or presentation. UF agrees to delete RTS Confidential Information from any such proposed publication or presentation material unless RTS agrees to allow its release. If RTS does not respond within the thirty (30) days, UF Investigators will have the right to publish the results without further notification or obligation to RTS.

6. **Inventions and Patents**:

a) "Background Intellectual Property" means any intellectual property owned or controlled by a Party as of the Effective Date or conceived outside of the Collaboration.

b) Neither Party shall have any claims to or rights in Background Intellectual Property of the other Party.

c) No license to the other Party under any patents is granted or implied by conveying proprietary or other Confidential Information to that Party. Should either Party desire to license the other Party's Intellectual Property, the Parties may choose to negotiate a license agreement with commercially reasonable terms. Nothing in this Agreement obligates either Party to enter such a license agreement.

d) If an invention is conceived exclusively by the employees of one Party in the performance of the Collaboration ("Sole Invention"), title to said Sole Invention and to any patent issuing thereon shall be in the inventing Party's name.

e) In the case of a joint invention, that is an invention made jointly by one or more employees of both Parties hereto in the performance of the Collaboration ("Joint Invention"), each Party shall have an equal, undivided interest in and to such Joint Invention(s).

7. **Use of Name for Publicity**: RTS agrees that UF may use its name to advertise and that RTS may be identified as a partner in the I-STREET collaboration. RTS name may be listed on the I-STREET website and in advertisements, news releases and other public relations publications regarding the project. Except as specifically provided for in this Agreement, neither Party shall use the name of the other Party or of any individual Party employee in any other advertising or promotional material without the prior written approval of the other. Notwithstanding any other provision of this Agreement, both Parties acknowledge that under Section 1004.22, Florida Statutes, UF shall be free to release the title and short description of the Collaboration, the name of the UF Investigator, and the amount and source of funding, if any, provided for the Collaboration, without prior approval of RTS.

8. **Compliance with Law**: The Parties shall comply with all applicable federal, state, local laws and regulations and nothing in this Agreement shall be construed to require either Party to violate such provisions of law or subject either Party to liability for adhering to such provisions of law.

9. **Independent Contractor**: UF shall be deemed to be and shall be an independent contractor and, as such, UF shall not be entitled to any benefits applicable to employees of RTS; Neither Party is authorized or empowered to act as agent for the other for any purpose and shall not on behalf of the other enter into any contract, warranty, or representation as to any matter. Neither shall be bound by the acts or conduct of the other.

10. **Liability and Insurance**: In the performance of all Collaboration activities hereunder:

a) Each Party hereby assumes any and all risks of personal injury and property damage attributable to the negligent acts or omissions of that Party and the officers, employees, and agents thereof to the extent permitted by Section 768.28, Florida Statutes. To the extent expressly limited by the sovereign immunity afforded to each party under 768.28, each Party agrees to indemnify the other against all claims, damages and liabilities arising from personal injury and property damage to third parties attributable to the negligent acts or omissions of that Party and the officers, employees, and agents thereof Nothing in this Agreement shall be interpreted as a waiver of either party's sovereign immunity as granted under Section 768.28, Florida Statutes.

b) Each Party shall obtain and maintain insurance or self-insurance, sufficient to cover their respective responsibilities under this Agreement. If requested, each Party agrees to provide evidence of such insurance to the other Party via Certificate of Insurance or other form.

11. **Termination**: This Agreement may be terminated at any time by UF or RTS by giving written notification to the appropriate Administrative Contact of the other Party.

12. **Notices**: The following are designated as Technical and Administrative contacts for the purposes of receiving notices under this Agreement.

**Technical Contacts**:

**For UF**:

Dr. Clark Letter, Research Assistant Professor
University of Florida Transportation Institute
512 Weil Hall
P.O. Box 116580
Gainesville, FL 32611-6580
clarklet@ufl.edu
321-298-4360

**For RTS**:

Jesus Gomez, Transit Director
City Of Gainesville Regional Transit System
34 SE 13th Road
P.O. Box 490 Station 5
Gainesville, FL 32627
gomezjm@cityofgainesville.org
(352)334-2600

**Administrative Contacts:**

**For UF**:

Kaden B. Canfield, Assistant Director
Division of Sponsored Programs
207 Grinter Hall
P.O. Box 115500
Gainesville, FL 32611-5500
ufawards@ufl.edu

**For RTS**:

Jesus Gomez, Transit Director
City Of Gainesville Regional Transit System
34 SE 13th Road
P.O. Box 490 Station 5
Gainesville, FL 32627
gomezjm@cityofgainesville.org
(352)334-2600

13. **Miscellaneous**: This Agreement (a) may not be assigned or transferred by either Party without the other Party's prior written consent, and (b) constitutes the entire understanding of the Parties with respect to the subject matter hereof.

14. **Agreement Modification:** The Parties may only modify this Agreement by a written instrument signed by both Parties. A purchase order may be used for billing purposes only and may not modify the terms and conditions of this Agreement.

IN WITNESS WHEREOF, the Parties have caused this Agreement to be executed by their duly authorized representatives.

| City of Gainesville Regional Transit System | University of Florida Board of Trustees |
| --- | --- |
| By: [signature] | By: Rob Luetjen |
| Name: MALISA MCCREEDY | Name: Rob Luetjen |
| Title: DIRECTOR OF MOBILITY | Title: Procurement Agent III |
| Date: 12.11.2018 | Date: 10/18/2018 |

Approved as to form and legality:

[signature]
City Attorney's Office

12/3/18
Date

Accepted and acknowledged by:

[signature]
Principal Investigator

[signature]
Department Chair

**Exhibit A**
**Collaboration Terms**

The University of Florida (UF) and its Transportation Institute (UFTI) and the Gainesville Regional Transit System (RTS) have partnered to deploy the Mobileye Shield+ solution on RTS transit buses. The University of Florida has a task work order and master agreement with the Florida Department of Transportation to procure and install the Shield+ solution on 10 RTS buses. UF will evaluate data generated from the equipment and provide a report to FDOT and the City of Gainesville regarding the effectiveness of the technology.

The main goals of the project are to:

- Improve mobility and safety on campus and around Gainesville
- Improve operations and safety of RTS' busses and transit system
- Quantify the minimum criteria for operators to safely engage with the Shield+ solution
- To become a model nationally and internationally for the use of advanced technologies to enhance transportation

**In order to further those goals, the Parties have entered into this Collaboration in which RTS will:**

- Work with Rosco Collision Avoidance, Inc. and UF to install equipment on identified RTS buses.
    - Said Equipment is more specifically described as:
      **Mobileye Shield+ system which includes 3 in-cab displays, 4 externally mounted cameras and various wiring harnesses.**

The Equipment will be used to collect data regarding incidents and near incidents with pedestrians and bicycles.

- Work with Rosco Collision Avoidance, Inc. to repair, maintain and replace the Equipment, as necessary, to ensure its safe operation as covered by the Warranty and Service agreement with Rosco Collision Avoidance, Inc.

- Work with UF to submit documented repair claims to the Florida Department of Transportation for repair and maintenance not covered under the existing Rosco Collision Avoidance Inc. agreement.

- Collaborate with UF on Generated Data analysis and evaluation.

- The City of Gainesville will retain the equipment at the conclusion of the study. The City will have the option to extend the service contract as identified in the end-user agreement between the City of Gainesville and Rosco Collision Avoidance Inc.

- Work in cooperation with the City of Gainesville and other I-Street stakeholders to accomplish the goals of this Collaboration.

- Provide UF with Background Data specifically described as bus identification numbers and route information regarding equipped buses.

**And UF will:**

- Work with RTS for target route and bus selection and installation.

- Pay for the acquisition and installation costs for a minimum of ten (10) 40' Gillig rigid buses. At the conclusion of the study all equipment will be retained by the City of Gainesville.

- Work with RTS and other relevant I-Street Stakeholders to identify and deploy the proposed system.

- Collect, analyze and store the Generated Data using the I-Street Data Analytics Platform.

- Collaborate with RTS on Generated Data analysis and evaluation.

# Appendix G – Gainesville RTS Driver Training Material Provided by Rosco Trucking LLC

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The driver training material was executed using a PowerPoint format containing video lessons. The project final report is accompanied by a supplemental file that contains this PowerPoint with the filename “Shield+ Operator Training.pptm”.

# Appendix H – Benefit-Cost Analysis Tool

The project final report is accompanied by a supplemental file that contains this spreadsheet tool with the filename "ADAS-BCAnalysisTool.xlsm".