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Microsimulation of the Impact of Access Management Practices to Pedestrians

FINAL REPORT

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16. Abstract

The study applied microsimulation to analyze the impact of access management (AM) to the operational performances of vehicles and pedestrians. A conceptual model was developed in VISSIM and VISWALK to examine the effect of access and signals density on different median types to the travel speed, travel time, delay and stopping. Access density, signal density, and presence of median were simulated in a scenario base analysis. The model scenarios shifted through changing both access density and signal density with no median, raised median and TWLT lane to provide interactions of arterial corridors in Nashville. The effect of access density on speed, delay and travel time was very vivid for the vehicles within the corridors showing speed decreasing with the increase in access density while delay increased and the number of stops increased. Additionally, as signal density increased, a decreasing pattern in corridor vehicle speed was observed. Pedestrian performances changes were less dramatic indicating that access density had a minimal effect on the pedestrian speed operations. The same trend was observed on signal density which affected pedestrian speed by a small decrease as signal density increased. The findings may provide useful understanding to state policy makers in implementing Access Management guidelines.

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CHAPTER 1: INTRODUCTION

1.1. Overview

The thrust of this project fell under the vital role which transportation system and network play in ensuring livability of communities through safe and efficient transportation services. In particular, this study focused on the impact of access management (AM) practices to pedestrian operations. Key elements were access management practices that impact pedestrians including crossing streets, access density, traffic control types, and signal density, conflict points, number of lanes, median types, crosswalk widths, sidewalk widths, shoulder widths, median type and widths and traffic circulation. The idea is to evaluate how pedestrian operations and safety are impacted by different access management practices. The study correlated through microsimulation the impact of these access features to pedestrians operations by evaluating their maneuverability with respect to pedestrian flow, pedestrian travel time, pedestrian travel speed and pedestrian crossing density/spacing.

1.2. Background

The growth in commercial and residential zones create access points and driveways which results in traffic conflict points hence triggering access management strategies and features. Access management plays a vital role in ensuring safety and improving traffic operations for pedestrians and vehicles alike. Access management can be described as regulation of design, spacing and operation of driveways, intersections, and medians [1]. A number of states in the United States have developed access management guidelines for different road features including Florida, Texas, Kentucky, Colorado, Wisconsin and many others. The state of Tennessee has developed manuals that regulate driveway permits [2] but no full comprehensive guidelines have been outlined. While various researches have utilized the effects of access management features on other states, there is limited resource on the effect of these features in the state of Tennessee. Though faced with challenges, access management is key factor in satisfactory traffic safety and operations in most busy corridors [3]. Access management is the process that provides access to land development while simultaneously preserving the flow of traffic on the surrounding system in terms of safety, capacity and speed. It is a way of regulating driveways, median openings and types, and number of turns in the roadway to ensure safety and efficient movement [4]. In developing access management recommendations in Texas, it was suggested that all factors should be closely examined including land use, design features, intersections spacing (signalized and unsignalized), corner clearance, median spacing, left-turn treatments, auxiliary lanes and location [5]. A different study in New Hampshire outlines that in addition to the median types, signal spacing, number of access points or driveways are also key factors in access management techniques [6]. The impact of access density and signal density have been thoroughly discussed by different researchers [2] [7] [8] whereby the effects of access points or driveways are considered to limit sight distances, create conflicts and reduce operation speeds. Literature shows that access density control can be achieved with effective driveway permits that allows continuous traffic flow on the main corridor with minimal interruptions [2]. Traffic signals placement and location are subjective to improve safety but failure to determine adequate cycle lengths can reduce speeds and cause delays [5]. The study [5] highlighted potential undesirable levels of services existed in areas with higher cycles lengths, as well as closely spaced signalized intersections. Long uniform signal spacing was accessed to be preferable to traffic flow during peak periods.

Practices in street planning and access control also noted median types can influence operations and affect traffic safety of the network [9]. Median types either raised (non-traversable) or traversable can allow or restrict turning movements to opposite side streets and driveways. Some traversable medians such as two-way left turn lanes (TWLT) allow continuous flow of traffic and also they provide storage for turning traffic added [2]. Full median openings and directional opening can be utilized to limit access as per driveway needs and requirements. Raised median design offer limited access by providing open access at signalized intersections and other major driveways [5]. This study was aimed at developing microscopic simulation models using VISSIM software to analyze the impact of access features to the mobility and accessibility of vehicles and pedestrians. Traffic simulations refer to the representation of a real time traffic scenario on a secondary platform or system to access various performances metrics [10] [11]. The use of simulation analysis has facilitated easier traffic operations and safety understanding before and after implementations of transportation facility features such as access management. The study focused on analyzing the impact of access management facilities on vehicle and pedestrian operations on selected major corridors in Nashville, Tennessee. The paper evaluated vehicles and pedestrian operations such as speed, delay and travel time with respect to median types, access density and signal density.

1.3. Access Management Practices

Lack of adequate access management is listed as one of the major factors leading to roadway crashes [12]. According to the TRB Manual, access management refers to the process of providing access to land development while simultaneously preserving the traffic on the surrounding street in terms of safety, capacity and speed [13]. Good access management begins at the planning level and proceeds through design, construction and maintenance. Well executed access management can appropriately balance traffic operation and safety and efficiency in terms of ingress and egress to adjacent properties [14] [15]. Accommodation of pedestrians and bicyclist as part of AM configurations can maximize the safety and comfort of these type of road users [16]. Roadway crashes with pedestrian and or bicyclists' injury severities are attributed to access points hence a well-planned access management can reduce conflicts due to access point or street crossings [17]. Many previous studies have not exclusively addressed impacts of AM practices on the operations and safety of pedestrians and bicyclist. However a study by the U.S Department of Transportation (USDOT) [14] highlights that every driveway represents potential conflict points between motor vehicles, pedestrians, and bicyclists. In a study conducted in Texas, access controls was found to have led to the reduction of about 50 percent of driveways related crashes [8]. The same study showed an increase in access points lead to increase in crash risk while inadequate few access points reduces travel congestions and improves safety.

Majority of the studies concentrated on various individual aspects such as safer driveways and pedestrian walkways in relation to AM practices [14] [17]. A research by the Texas DOT described two major safety effects of AM in which increase in access density also increases crash rates, and corridors with non-traversable medians are safer than undivided roadways at high speeds and higher traffic volumes [18]. The same study found that excessively-wide streets encourage higher motorist speeds while high-volume multilane roads without safe crossings can contribute to pedestrians crossing streets at unsafe locations, particularly those who do not walk great distances to signalized locations. Land use decisions can also result in areas that are unsafe for pedestrians, for example, separating residential areas from shopping areas with high-volume of vehicles.

Micro simulations models have been used in various studies to evaluate the interactions between vehicles, pedestrians, bicyclist and the roadways. Campos and Monteiro [16] summarized parameters which can be used to analyze pedestrians and bicyclists into two categories based on urban infrastructure and environmental characteristics. In analyzing the characteristics relating vehicle-pedestrians interactions, a significant number of techniques have been used to relate the conflicts between the two. In a study conducted in UK [19], an automated video assessment of the pedestrians crossing at a location provided results that helped in identifying the conflicts situations between vehicle-pedestrians as well as injury severities resulting from their collisions. A different model employed by Wu and Zhuang [20] to study how pedestrian gestures relate to drivers at uncontrolled mid-block road crossings derived three basic requirements (visibility, clarity and motive power) that would be used to explore how pedestrians can affect the signaling at crossings. A number of gestures where set to be observed on-field practices, the effect of the gesture established that two particular gestures (extended arm and raised arm) led to an increase in driver yielding at crossings. The relation between clarity, visibility and familiarity of the gesture to the driver also determined the rate of yielding between drivers. The study recommended that drivers as well as pedestrians should be trained to understand and use appropriate gestures to increase safety on these crossings [20].

Extended studies exploit the use of traffic simulations models to represent different scenarios on roadways that can be used to design safer roads for both vehicles and pedestrian-bicyclist [21] [22] [23]. The study by Abdel-Aty and Haleem [7] found that the link between AM and traffic safety can be related to median classification and spatial effects. The study analyzed different types of medians that could possibly exist in the surroundings of unsignalized intersections and access points to compare results of both median related crashes and intersections related crashes. The results showed than open median types were the most hazardous, also single vehicle crashes were the most frequent median related crash patterns seconded by right angled crashes. In addition, the bivariate probit model showed that other factors affecting median related crashes such as median width and speed limits point out that the medians types and median related crashes are interrelated [7].

CHAPTER 2: STUDY CORRIDORS CHARACTERISTICS

2.1. Study Corridors

This study utilized arterial and local roads which are the main pathways for commercial activities and pedestrian movement in Nashville area. The selected arterials were considered because they feed into the freeways and are characterized with speed limits between 35-50mph. Most of the study roadways selected have a common classification of being principle arterial roads, with mixed land use characteristics infringing towards commercial and residential. Retail shop strips, shopping complex, restaurant areas, multistory resident buildings, family housings and a few land parcels undeveloped. Table 2.1 shows study corridors characteristics including traffic volume, length, classification, access density and others.

Table 2.1: Study Corridors Characteristics

Road name	Length (miles)	No. of signalized intersections	No. of unsignalized intersections	No. of Lanes	Access Density (per mile)	Traffic Volume (vpd)
Charlotte	1.5	5	17	4	44.6	29000-25000
Jefferson	1.57	7	11	2	28.0	13000-10000
Nolensville	1.14	3	7	4	17.5	30000-34000
Gallatin	1.39	9	13	4	43.1	23000-25000
Lebanon	1.1	3	4	4	35.4	32000-36000

The study developed three (3) base scenarios for comparison with access density changes.

A. **Median Type (No signal)**: A corridor with 51 access points was analyzed and the variation in speed, delay and travel time with respect to raised median, TWLT and undivided roadway was observed. Under this scenario, different access density with medium traffic volume inputs were created along the corridor. The base model created used a non-traversable/raised median as well as the effect of undivided median with varying access density. In addition, the scenario evaluated the effects of a two-way left turn lane (TWLT) to the variation of access density.

B. **Signalized with TWLT**: Signals were added to Scenario A on a TWLT median type. Different signal densities were analyzed and the variation in speed, delay and travel time recorded. With TWLT, the 1 mile section was evaluated with the effect of adding signals (varying signal densities).

C. **Signalized with both TWLT and raised median**: Under this scenario, the corridor is divided into segments with TWLT and segments with raised medians. Left turn movements at the intersections were also added at each approach. Changes in speed, delay and travel time was recorded for each signal density variation.

2.2. Simulation

The study created interactive network with varying access density, roadway features and pedestrian walking spaces within the model. In creating a valid model that imitate pedestrian behaviors and car maneuvers, links and connectors in VISSIM were used. Medians were coded as an obstacle or area between two opposing links (lanes) while TWLT were coded as overlapping links in opposite directions with priority to the vehicle entering first. Connectors in VISSIM helped to prevent break of traffic flow and ensured continuity throughout the network. Default parameters available in VISSIM such as driving behaviors, lane changing parameters and percentage of passenger cars and trucks were adjusted to match available data. Traffic input such as design hourly volumes (DHV), turning movements and percentage trucks were estimated from available data along the corridors. Traffic demands represented the existing conditions for development of the base model. Traffic volume and traffic routing decisions provide the network with vehicle inputs, compositions and turning movements. Using data obtained from Tennessee Department of Transportation (TDOT), traffic volume, peak hour factors and directional splits were gathered. Default vehicle inputs in VISSIM assumes all vehicle types are uniformly distributed. Traffic data showed traffic mix was not uniform with passenger cars having the highest volume in the traffic flow stream followed by SUV and trucks. The data values were entered in the model as study vehicle compositions with considerations on the volume type and time-interval selection. This method was opted by DKS Associates [24] to simulate 15 minutes volume increment as well as enter volume inputs as exact. Simulation results are averaged over multiple runs with different seeds thus exact parameter prevents randomness in the volume inputs of the network. The selected study corridors differed in geometry, access and roadway features, vehicle compositions and others. Specific parameters relating to each corridor was necessary to replicate each roadway to its existing conditions. Since most of the corridors were urban arterials, according to DKS Associates [24], rarely can vehicles attain the free flow speed due to signal interruptions thus speed distribution input was suggested to be linear using +/-5 of the posted speed limit. The posted speed limits along the study corridors are shown in Table 2.2 as well as VISSIM range inputs.

Table 2.2: Posted speed and VISSIM distribution range

Road name	Charlotte Pike	Jefferson Street	Nolensville Pike	Gallatin Pike	Lebanon Pike
Posted Speed (mph)	45	35	40	40	45
VISSIM Speed range (mph)	43-47	33-38	38-43	38-43	38-43

2.3. Traffic Control

Two types of traffic controls were used; stop and signal controlled intersections. Ring barrier signal controller (RBC) was used allowing manual configuration of cycle lengths [25]. Ring barrier signal controller (RBC) also provided splits for each approach to be defined and entered prior to selecting and defining signal heads for each approach at signalized intersections. Detectors were added on minor streets as most of the study corridors are semi actuated. Stop sign parameters were defined access points as the efforts to create driveways and junctions with a stop control operation. Stop signs provided the effect of yielding allowing mainstream traffic to move undisturbed. However, the gap allowances for vehicles to enter the mainstream was left as default. Vehicles coming from a minor street, that's from the access points which eventually join the major corridor, are forced to stop before continuing to the major street.

2.4. Setting Pedestrian Network

Pedestrian simulation is achieved by coupling VISSIM with VISWALK which is an integral part of the main simulation platform. Pedestrian flows were modeled using links acting as sidewalks on either side of the mainstream traffic. Movements was created from the network end to a point in the center and the direction reversed. The first model approach as crating pedestrians as specific vehicle composition known assigning pedestrians types and relative flows for each type. Activating pedestrians as vehicles allowed for continuity and flow, however, one of the limitations in this method is that pedestrian behavior and vehicle behavior are considered to be similar [25]. Movements of pedestrian follow the concept of vehicles with headway, queuing and lateral space. Additionally this approach does not allow opposing traffic to interact rather it creates a loop of movement which does not depict or reflect the actual movements. The second model approach involved creating pedestrian areas which can be the origin or destination of pedestrians. This method allows movement from specific areas, editing of actual pedestrian movements reflect a more realistic approach. Additionally, this approach allowed the use of pedestrian OD matrix, however, using pedestrian areas prevented mixed flow interactions between vehicles and pedestrians. For this study, a mixed flow of pedestrian and vehicles was necessary, therefore the study corridors were simulated with both links as pedestrian areas and other pedestrian areas only. The main objective of this approach was to create real interactions between traffic and pedestrian movements in the network. To create the pedestrian network the flowing steps were followed:

- *Pedestrian Areas*: Six (6) pedestrian areas were created representing origin and/destination along the corridor. For the purpose of creating pedestrian OD matrix, all areas were designated as origin and destination which allowed pedestrian input parameters to utilize most of the areas and create routes along the corridor. Pedestrian areas also served as termination points for end of routes and a flexible interaction of flow in opposing routes.
- *Pedestrian Compositions*: Pedestrian compositions were based on two types of pedestrians; man and woman. Pedestrian speeds were adapted according to the simulation preferences, using Fruin1 walking speeds distribution from a built in parameter as base. This speed distribution assumes an OGIVE curve between 1mph and 4mph with 85th percentile speeds being 2.9 mph and 25th percentile as 1.9 mph. Figure 2.1 shows the speed distribution for pedestrian using Fruin1 speed model.
- *Pedestrian Behaviors*: Movement of pedestrians is a reflection of behavior parameters adjusted or changed within the simulation. These parameters can increase flow, headways, counter flows, and make the pedestrians push more or less. Five components are available in shaping and creating preferred pedestrian movement, these include Tau, Lambda, Socio-isotropic and Socio-mean, noise parameter and reaction [25]. The study opted for a smaller tau value for faster movements, a lambda value slightly above the default was also used to make efficient counterflow for pedestrians travelling in opposite directions and a larger noise parameter which favored randomness in the pedestrians, other factors remained as VISSIM default values.
- *Pedestrian Volumes*: Actual pedestrian volumes were estimated based on activities, location and distances from specific study corridors. Pedestrian estimated volumes along the corridor depended on the destinations ranging from 15 to 5 pedestrians per hour.

- *Pedestrian Routing*: Despite the fact that adding pedestrians from the OD matrix option automatically created static routes to destinations, partial routes was needed to be defined. Partial routes directed pedestrians to follow specific paths to reach the destination areas. The use of partial routes allowed pedestrians to travel on links (used as pedestrian areas) as walking areas.

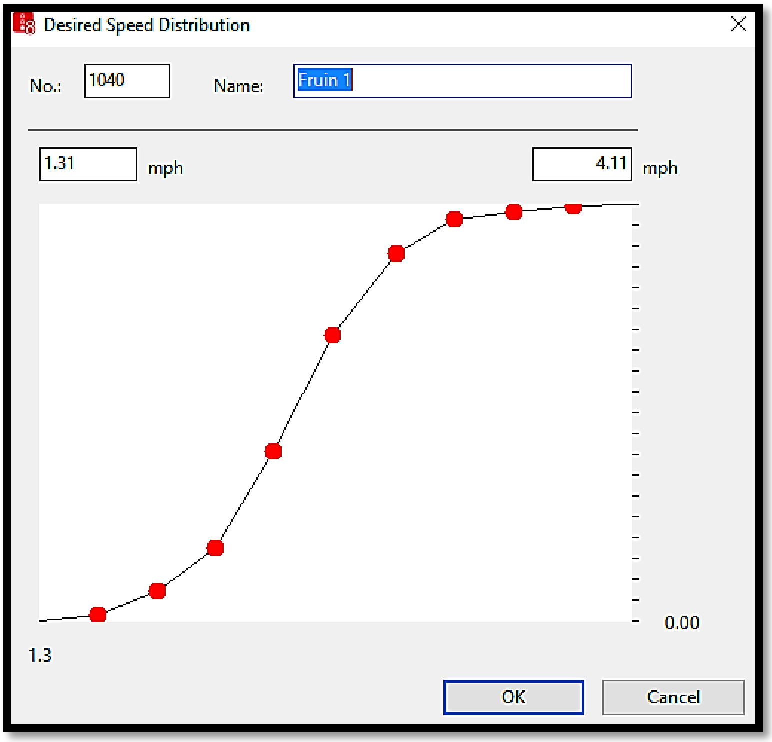

Figure 2.1: Fruin1 Pedestrian speed distribution

2.5. Defining Evaluations

Vehicle network performances were actuated, this allowed vehicle travel times, speed, delay, queue lengths, acceleration and others to be observed. Pedestrian performances were also collected and observed to evaluate the effect of varying corridor access management features. Simulation run was analyzed for 4200 seconds which is equivalent to one hour run with 10 minutes warm up time. Data collection and network performances was set to start at 600 seconds from the start of simulation that allowed the network to populate itself with vehicles and pedestrians during the first 10 minutes. The models were simulated for 10 steps per second which is a recommended value for producing final results for evaluations. Random seeds account for different set of behaviors that occur in traffic streams. The model was set to 10 different random seeds performed in 20 simulation runs. A test run was conducted which returned a number of errors from the model. Using the message board in VISSIM errors were traced and corrected before calibrating and validating the network for comparison among the scenarios. Network calibration compared the desired speed and actual network speed as well as the simulated and input volume of which both had an error less than 5% that validates the model.

CHAPTER 3: RESULTS

3.1. Defining Evaluations

For the base model and the need to create simulation reference for comparison, inputs such as traffic volumes (vehicles and pedestrians), turning movements and signal times were maintained for all scenarios. Each of the scenarios simulated was assessed on the same parameters with relation to vehicles operations and pedestrians. The focus on the selected scenarios was based on operation measurements such as the average speed of the corridor, average corridor delay, mean network travel time and average stops on the corridor. The three (3) scenarios developed are presented and the operational analysis are plotted and compared.

3.2. Scenario 1: Effect of Median Type

Median type simulations compared raised median, two-way left turn lanes (TWLT) and undivided roadways, Figure 3.1. The goal was to observe which of these roadways is affected the most in terms of speed, delay, number of stops and travel time. Results show that average speed of vehicles in the network was decreasing with the increase in access density, Figure 3.1. For raised median, the network speed decreased from 38mph to 30 mph for the upward variations of access density. Two-way left turn lane corridors displayed similar trends in speed. Number of stops in VISSIM evaluation module consists of all stops a vehicle makes within the corridor. This includes stop sign stops, signal stops and vehicles waiting for a left turn maneuver. The average stops per vehicle increased with access density from 0 to 1 stop per vehicle in TWLT and raised median areas. In undivided segments, the variance of stops was widened and stops increased from 0 to 2.5 stops with access density increase. Undivided segments also showed network speed reducing as access density increased. However, the deviation of the observed cases is also visible as shown in the Figure 3.2. Undivided roadway speeds were lower than for TWLT and raised median and had a wider dispersion between the minimum and maximum values as compared to the latter two.

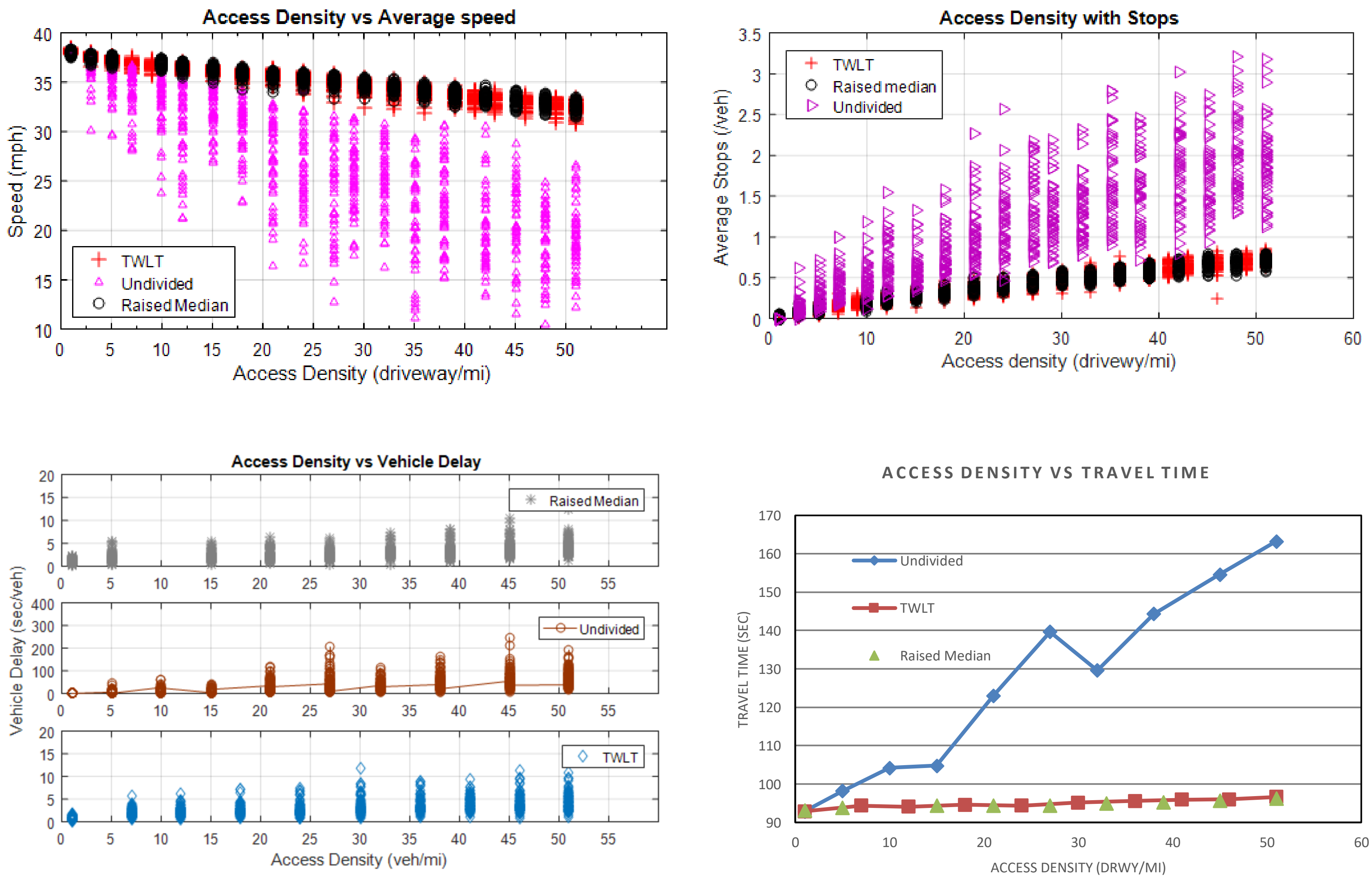

Figure 3.1: Effect of Varying Median Types

3.3. Scenario 2: Effect of TWLT

In scenario 2, the effects of a two way left turn lane were analyzed with varying signal density. From scenario one (1) above, TWLT had a higher travel speed than undivided roadways. The goal in this scenario was to compare the effects of access density and signal density with TWLT. Measure such as speed, delay, number of stops and travel time are compared. The results are shown in Figure 3.2. As the signal density increases the average speed of vehicles in the network decreased. Also as access density increased average speed was reduced in the same manner as it was observed above. The speed pattern on one signal density shows a clear decreasing trend as access density increases. As signal density increases the pattern becomes less clear especially for 3 and 4 signal densities. Additionally speed reduction is observed with the increase of signal density. The effect of 3 signals per miles also showed a wide spread of outliers in the between 0 to 5 access per mile. This effect is not fully explained however the network signals and access spacing were not evenly matched. The number of stops per vehicle for TWLT segments as signal density and access density are varied. The variation of access density observed concur with most literature that frequency of stops increase as access density increases. The trend is well illustrated in the Figure 3.2 for one and two signal density simulated segments. For three and four signal density roadways, the trend becomes less clear. Additionally the increase of signal density increases stops in the segments where the model for one signal density showed a maximum of one stop per vehicle if the access density was maximum. As the signal density is increased, the number of stops increased from 0.5 to at least 2.0. The variation of 3-signal density still showed several outliers on 0 to 5 access density. TWLT segments showed less delay than undivided roadways in the first scenario. Access density increase/decrease did not show any effect on one and two signal density TWLT segments. However, the additional of signal density for one and two showed delay increased according to Figure 3.2. The maximum delay increased from 50 seconds per vehicle to more than 100 seconds per vehicle for two-signal density. Likewise, for three and four signal density there is no apparent effect on delay due to access density variation. Signal density continue to increase delay in this type of roadways, with a maximum value of 200 seconds for three and four signal density. The outlier of 0 to 5--access density variation is also observed in the figure for three signal density results. The average travel time does not change significantly with increase or decrease of access density. However, the variation of signal density shows travel time increases with an increase in signal density. Average travel time values for one signal density are between 120 and 130 seconds, for two-signal density the value increases to between 140 and 150 seconds. That is, as the signal density gets higher, so does the travel time.

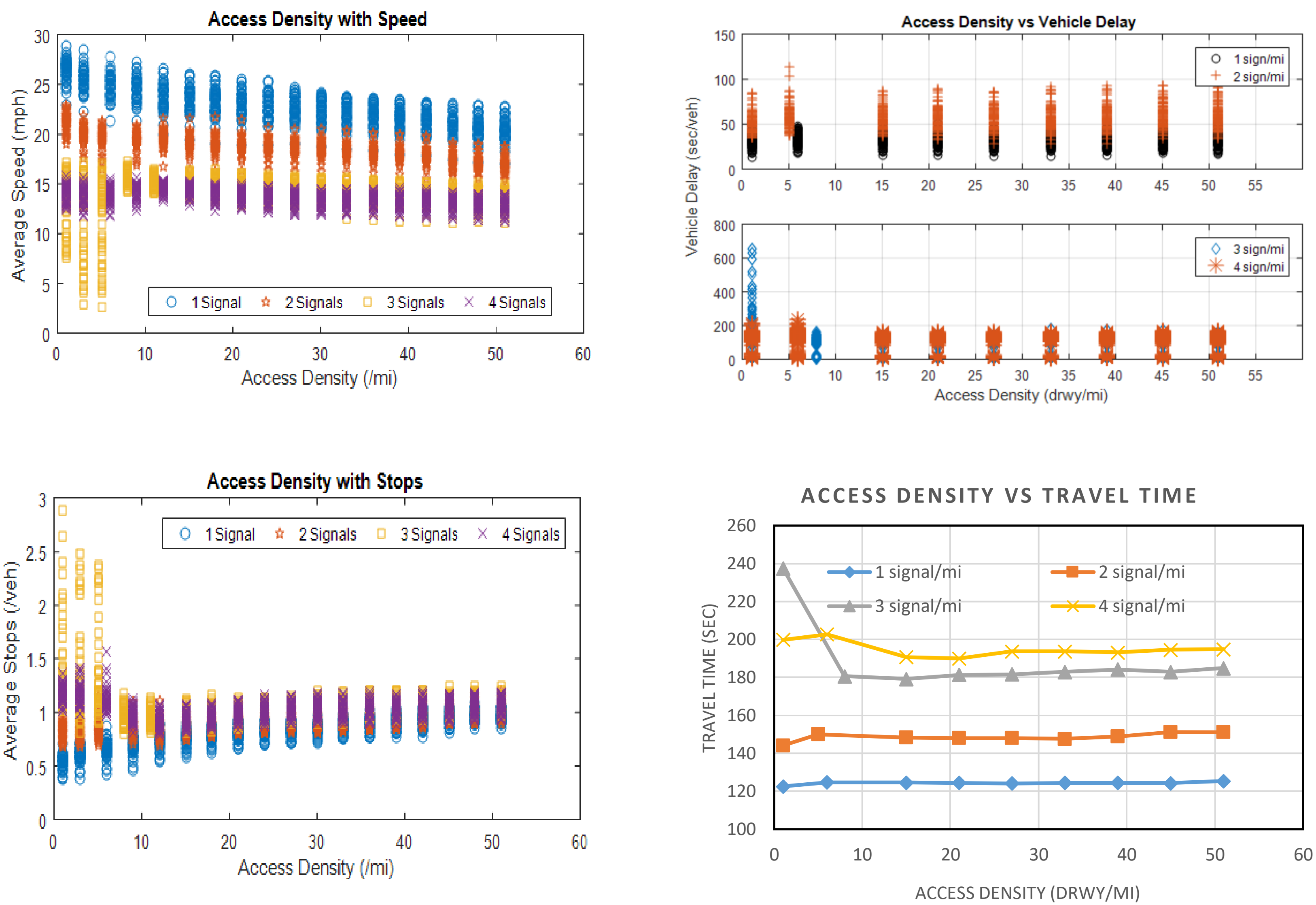

Figure 3.2: Effect of TWLT

3.4. Scenario 3: Raised Median and TWLT

For the third scenario, the model alternated raised median segments and TWLT segments on specific sections of the roadway. The simulations compared the effect of signal density on a composite of the features. Similarly, the goal was to evaluate the operational effects on vehicles on average travel speed, average delay, and number of stops as well as travel time. Similar to most of the above results, average speed of vehicles in the network decreases with increase in access density, Figure 3.3. As access density increase average speed was reduced but at a lower rate than for the other scenarios. For one and two signal density, the decreasing rate is observed more clearly than for three and four signal density. The results also show the speed of vehicles was decreased with signal density increase. The vehicle speed range for one, two three and four signal densities were from 32mph to 26mph, 27mph to 22mph, 20mph to 15mph and 28mh to 14mph respectively. Furthermore, the overlap of the speed is observed in three and four signal density thus average speed for vehicles shows less difference as signal density increases. The number of stops increases with access density in which for one and two signal density the number of stops increased from 0.4 to 1.0 stop per vehicle. Since this scenario accommodated both two-way left turn lanes to decrease interruption of flow as well as limiting access with raised median segments, the number of stops increase consistently. Signal density variations also show a steady increase of stops from 0.4 to 1.6 for one and four signal density respectively. The results for four-signal density are not consistent on access density increase especially between 0 and 15. Other than that, signal density variations have an overlap that is steady between one and two, two and three and more spread out in three and four-signal density.

Average delay measurement results for this scenario are shown in the Figure 3.3. The effect of access density on the delay per vehicle in the network is constant throughout the variation meaning, no apparent trends were observed for access density. On the observations related to signal density, the average delay increases with the increase of signal density. The maximum delay for one signal density is 40 seconds/vehicle followed by 60 seconds/vehicle at two signal density and 100 seconds/vehicles for three and four signal density. The increase in signal density increases the delay as observed on one and two signal density, however for three and four the signal density variations appear to be constant or show no apparent change in delay measurements

The travel time assessment in this scenario is consistent with much of the results above. Much like in the delay results, there is no significant variation in travel time as access density changes. The change in signal density however creates significant impact on travel time. As signal density increases, the travel time also increases. For a single signal per mile the travel time is just above 100 seconds per vehicle, this time increase to 130 for two signals per mile and consequently to approximately 180 seconds for four signal density. The scenario limits access on some parts of the one mile simulated corridor by raised median while allowing access on the other half of the corridor through TWLT.

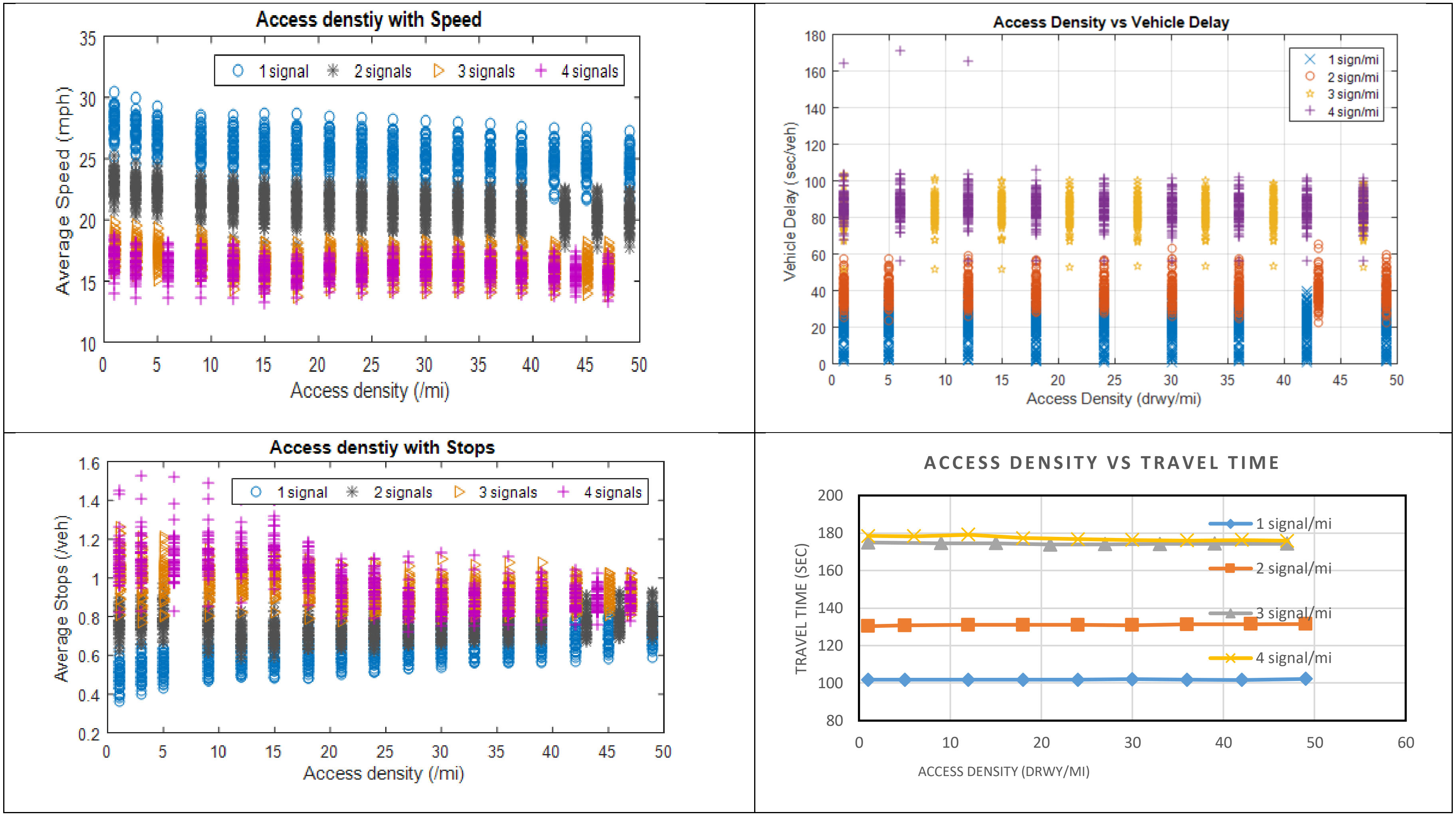

Figure 3.3: Effect of Raised Median and TWLT

3.5. Pedestrian Simulation Results

Pedestrian simulations measures were also obtained with the vehicle evaluations. The analysis opted to include pedestrians in the system to simulate the interactions on arterials with vehicles and access features as well. The results show that pedestrian speed did not vary with access density nor influenced by signal density. Figure 3.4 is a box plot representation of the different scenarios results. The overlapping in the box plot show there was no significant variation in pedestrian speed as access density increases. The change observed from 45-access density is also significantly low.

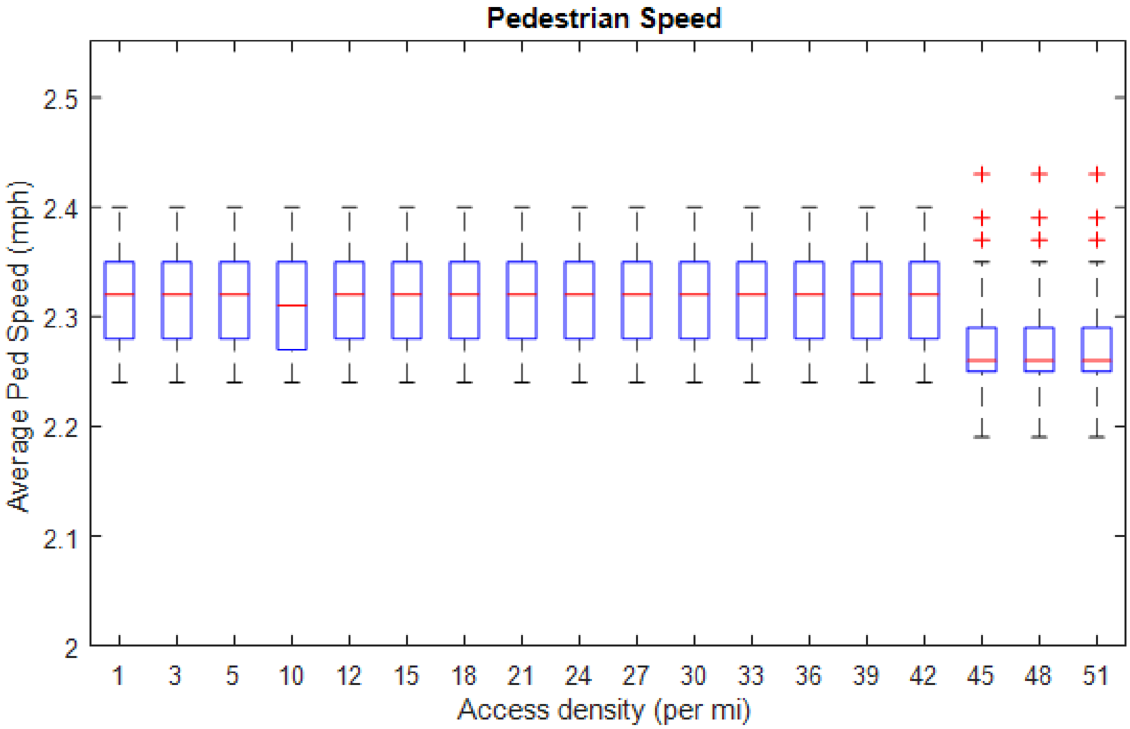

Figure 3.4: Pedestrian Speed with Access Density

Travel time measurements are set on four (4) parts along the corridor and analyzed for the three (3) scenarios. The evaluation of travel time is to observe the influence of access density and signal density on the time it takes to move from set points within the corridor. For scenario one, the three median options, undivided, raised median and two-left-turn lanes show that raised median allows pedestrian to travel faster than on undivided and TWLT. Raised median limit interaction from opposing traffic which is not the case for undivided and TWLT lanes consequently reducing the interactions at access points between pedestrians and vehicles. The second scenario analyzed TWLT effects by allowing interactions and adding signal density to the simulation. Access density was observed not to affect pedestrian travel time much like for speed. Regardless of this, the effect of signal density showed increase in travel time as signal density increases. The travel time for a single signal per mile was at 11.6 minutes for a defined travel distance while that of four signals per mile is 13 minutes for the same distance, Figure 3.5. The increase in travel time can be due to the increase in stops at signal and waiting time at signals. The last scenario combined raised median and TWLT at equal parts within the corridor segment. Similar to the other results no significant effect was observed on the pedestrian travel time.

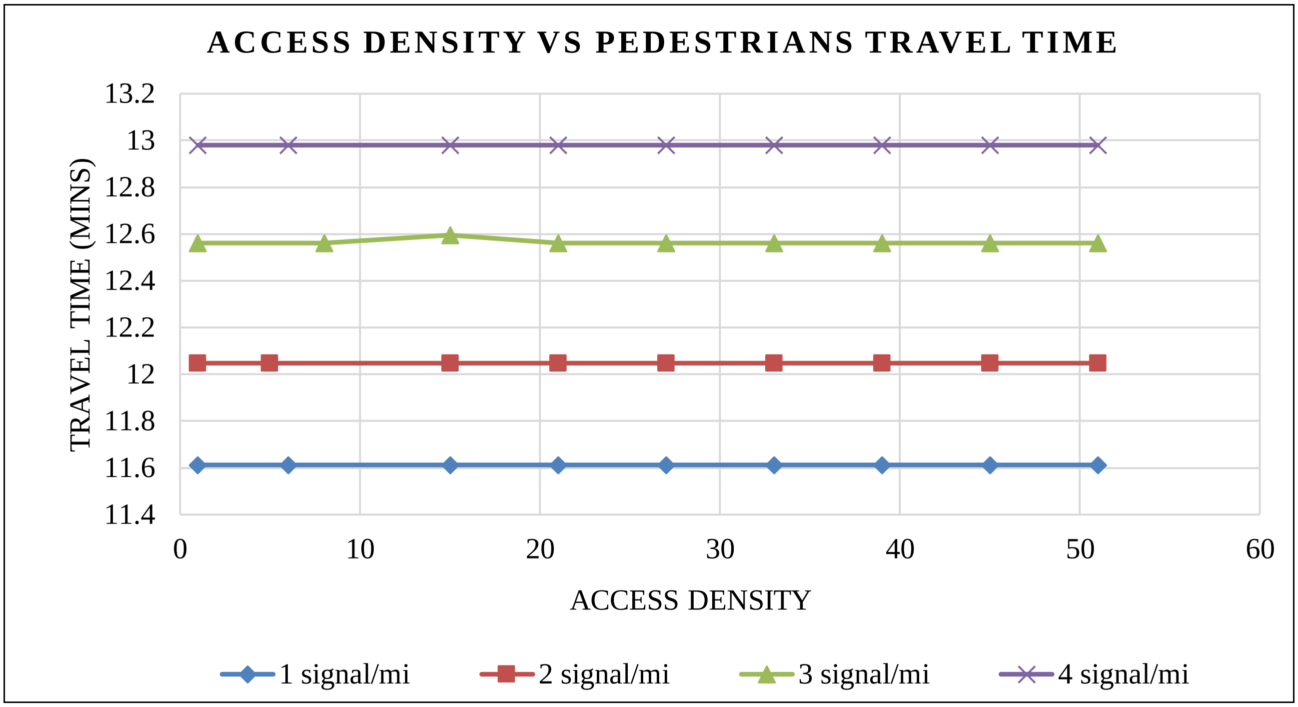

Figure 3.5: Access Density with Pedestrian Travel time

CHAPTER 4: CONCLUSION AND RECOMMENDATIONS

The study assessed effects of some Access Management features on vehicle and pedestrian operations. The operations performance measures such as speed, delay, stops and travel time were evaluated through microsimulation and modeling. Five major corridors with substantial access densities and different median types located in Nashville Tennessee were evaluated. Three median types were modeled while varying access density as well as signal density. VISSIM and VISWALK microscopic simulation was then run to replicate the corridor characteristics and the operational performances of the vehicles and pedestrians were observed. Medians were coded as an obstacle or area between two opposing links (lanes) while TWLT were coded as overlapping links in opposite directions with priority to the vehicle entering first. Of many interesting observations, the following were some of the findings noted:

- There is significant change in travel speed as access density changes along undivided median roadways compared to raised median and TWLT segments.
- There is significant change in the number of vehicle stops and vehicle delays as access density changes along undivided median roadways compared to raised median and TWLT segments. In other words, access density influences travel time more on undivided roadways than compared to other type of medians.
- The travel speed decreases along TWLT segments as signal density and access density
- Delays and travel appears to be more sensitive to changes in signal density compared to changes in access density.
- Neglecting the median type, changes in the access density and signal density do not affect much the average pedestrian speeds.
- Pedestrian travel time are at lowest along raised median areas compared to undivided and TWLT counterparts.

Most of the simulation assessments carried out involved creating a tailored corridor with traffic reflecting existing conditions. Specific simulation features which can provided more understanding to the effects of AM features to both pedestrian and vehicles is highly recommended. Future directions of the interactions should explore corridor specific parameters such as pedestrian dense corridors and shared spaces where interactions between pedestrian and vehicles is inevitable.

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