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USING CONNECTED VEHICLE TECHNOLOGY TO IMPLEMENT A PAY FOR PRIORITY SYSTEM AT SIGNALIZED INTERSECTIONS

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USING CONNECTED VEHICLE TECHNOLOGY TO IMPLEMENT A PAY FOR PRIORITY SYSTEM AT SIGNALIZED INTERSECTIONS

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ABSTRACT

This research evaluated a mixed vehicle environment that included connected and non-connected vehicles in which connected vehicles (CV) were allowed to pay a small fee to request priority at a signalized intersection, similar to a transit signal priority system. Connected vehicles with signal priority were simulated with penetration levels ranging from 10% to 100% as well as with various priority directions (all directions, major street movements in both directions, and major street movements in the direction of highest flow) being allowed to request priority. These scenarios were compared to optimized signal timings to determine the effectiveness of the technology in terms of average delay, then benefit-cost analysis was performed to assess the viability of this strategy that allows connected vehicles to receive signal priority for a fee.

It was discovered that connected vehicles with signal priority experience less delay than non-connected vehicles for all priority direction scenarios studied up to a certain point. When all directions and major street movements in both directions are allowed to request priority, the advantage for CV was statistically significant up to 20% CV penetration. When priority was only allowed to be requested in the direction of highest flow, CVs experienced lower delay at a statistically significant level up to 40% CV penetration levels. Above these thresholds connected and non-connected vehicles experience similar delay. Average delay for all vehicles on the network, including connected and non-connected vehicle types, was also analyzed and revealed that average delay tended to increase as the CV penetration levels increased. When priority was permitted in only the major direction of travel, the average delay for all vehicles on the

network was significantly less than the base scenario for up to 50% CV penetration levels. Delay for all vehicles types was higher than the base scenario when priority was permitted in all directions and in both directions on the main corridors.

A benefit-cost analysis was performed for the major flow direction priority scenario because it was the only scenario that outperformed the optimized signal timing scenario with no CV. A benefit-cost analysis based solely on revenue generated from CV requesting priority at intersections and the system cost resulted in a benefit-cost ratio greater than 1 at as low as 20% CV penetration levels. When the benefit-cost analysis added the benefit of decreased network delay for all vehicles, benefit-cost ratios as high as 3 were observed at 10% CV penetration levels.

DEDICATION

I dedicate this work to my parents, Mark and Tena Gende, for their steadfast support and unconditional love that has helped me become the woman I am today.

Also, to my best friend and love of my life, Andrew Tamashunas, for always making me laugh and reminding me, again and again, that all hard work pays off in the long run.

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CHAPTER ONE

INTRODUCTION

1.1 Problem Statement

According to the most recent Urban Mobility report, the average American spent 38 hours in traffic congestion in 2011 (Texas A&M Transportation Institute 2012). Some of this congestion occurs at signalized intersections where inefficient signal phasing causes delay (Goodall 2013). The cost of widening roadways in an urban setting has become more expensive than ever before, and many times it is not viable due to right-of-way restrictions, thus adding additional lanes at intersections is a less viable option (Wachs 2006).

As a result researchers turned their efforts to finding ways to increase efficiency at intersections without adding lanes. In the 1990's adaptive traffic signals on urban corridors running on SCATS, SCOOT, and RHODES logic began to be widely implemented (Stevanovic 2010). These systems took advantage of traffic detectors which allowed traffic signals to perform better than traditional actuated signals because it introduced other parameters like minimum green time, maximum green time, and passage time which improved signal phasing adjustment (McShane et al. 2013). Unfortunately, these systems are still limited in how effective they can be at reducing delay at intersections due to the limited range of equipment used to detect traffic. For example, the highest recommended sensor setback for a road with speeds of 40 mph is 170 feet with some agencies limiting the distance to 120 feet (Klein et al. 2003).

The inability of these systems to consistently reduce traffic delay at intersections became a major problem for transit agencies. Transit riders expect for busses to be reliable and arrive to stops according to a pre-set schedule. However, this task can be very difficult during peak hours when traffic backs up at busy intersections. One of the strategies employed to combat this issue is transit signal priority (TSP). TSP works by allowing transit vehicles to communicate with equipped traffic signals to give notice that the vehicle is approaching the intersection. With this knowledge the controller then adjusts signal phasing at the intersection to allow the transit vehicle to continue on its route in a timely manner. TSP has been thoroughly researched and implemented over the past couple of decades. According to most studies, TSP results in better schedule adherence for transit due to decreased delay at intersections, while having a minimal impact on cross-street traffic as long as the cross street is not nearing capacity (Garrow and Machemehl 1997; Smith et al. 2005). A 2013 survey showed that 26% of transit agencies use transit signal priority for their fixed route bus services (Gordon and Trombly 2014; Gordon and Trombly 2014).

The concept behind transit signal priority systems may soon be able to be applied to other vehicles as well. Recent advancements in short to medium range wireless communication technology, including dedicated short range communication or DSRC with IEEE 802.11p protocol (IEEE Standards Association 2001), Wi-Fi, cellular, and infrared data link technology (Papadimitratos et al. 2009) has paved the way for vehicles to communicate with other vehicles (V2V) and surrounding transportation infrastructure (V2I), such as traffic signals. As these technologies become increasingly mature, governments have increased efforts in the development of standards and laws to require vehicles to be equipped with communications devices. In early 2014 the National Highway Transportation Safety Administration (NHTSA) announced its intention to move forward with plans to enable V2V communication technology for light vehicles (National Highway Traffic Safety Administration 2014). Later that year NHTSA released a comprehensive report about the state of V2V technology and outlined exactly what research is still necessary before moving forward with rule-making for a deployment-level V2V communication system mandate (Harding et al. 2014). Intelligent transportation systems and connected vehicle technology related real-time applications have shown to be viable traffic management strategies to reduce traffic delay and improve energy consumption (Ma et al. 2009a; Ma et al. 2009b; Bhavsar et al. 2007; Bhavsar et al. 2014). This rapid development of new technologies has led researchers to look at increasing efficiency at intersections using connected vehicle technology (CVT) to anticipate demand at an intersection and make adjustments to the signal phasing plan ahead of time instead of reacting to demand as current technologies allow.

While these technologies have the potential to have a major impact on the existing transportation system, it is becoming increasingly difficult to fund transportation projects. Traditional means of funding transportation projects, like the gas tax, are generating less revenue as inflation continues to rise and recent technological advances are drastically increasing vehicle fuel efficiency (Katz and Puentes 2005). Many innovative funding approaches have been explored to fund transportation projects, such as local sales tax initiatives and public-private partnerships. A common suggestion among professionals is that a more robust user fee finance system consisting of vehicle miles traveled fees or congestion pricing strategies can help mitigate anticipated transportation finance crisis by providing additional revenue while encouraging more cost-conscious travel behavior (Wachs 2006; Morris 2006).

The idea of paying for access to a roadway has deeps roots in the United States. In the early 19th century, the "turnpike era" resulted in thousands of miles of toll roads being built for wagon traffic in Pennsylvania, New York, New Jersey, Maryland, and a few other states (McCarty 1951). Today drivers are able to use transponders to easily pay tolls on toll roads and on high occupancy toll lanes. The introduction of connected vehicles into the transportation system may make this process even more streamlined (Kuennen 2011). If the payment process were to be more efficient it may result in more situations where users are asked to pay a fee for specific uses of the transportation system.

There is a growing body of research that proposes to use market-based strategies to control intersections in a connected vehicle environment. Suggestions for this type of control range from allowing some users to pay for enhanced service at an intersection to requiring all users to pay a small fee to use an intersection, to requiring travelers to outbid all other travelers at an intersection to be granted permission to use the intersection (Vasirani and Ossowski 2012; Isukapati 2014; Carlino et al. 2013). However, like with all user fees, these policies raise the ethical question about how access to vital transportation facilities should be controlled.

1.2 Objectives of the Thesis

This research will evaluate several aspects of a signal priority request strategy for connected vehicles to increase efficiency at intersections and generate revenue using connected vehicle technology. The first objective is to evaluate performance of a signal priority request system at different connected vehicle penetration levels and at different permitted priority directions for connected vehicle. Additionally, this research will identify a critical value for connected vehicle penetration level at which the connected vehicle signal priority system performs better than a non-priority system.

This research proposes that users be charged to request priority at an intersection therefore, the second objective includes a benefit to cost comparison for the connected vehicle supported signal priority system at different payment levels and different system cost estimates. The third objective is to anticipate some of the social implications of a "pay for priority" system by posing questions like, "What type of user will benefit most from this system?" and "Is that fair?"

1.3 Statement of Contribution

Connected vehicles will undoubtedly impact operation of traffic signals, however the question still remains as to what is the best approach to utilize connected vehicle data at signalized intersections. This research explores applying a strategy similar to transit signal priority for connected vehicles. A unique aspect of this research is that it proposes a payment plan to be considered in conjunction with the priority system to help offset the costs of intersection improvements.

The findings of this research will expand our understanding of how connected vehicle information may be used at signalized intersections. Additionally, the idea that connected vehicle technology could allow users to pay for priority at a signalized intersection will encourage more discussion among policy makers about the place that this type of user fee may have in a connected vehicle environment.

1.4 Organization of Thesis

Chapter 2 reviews literature pertaining to the use of connected vehicle technology to increase efficiency at intersection, market-based approaches to intersection control, public perception of fee-based transportation strategies, and the expected cost of a traffic signal system that can communicate with connected vehicles and adjust its timings plans. Chapter 3 goes into detail about the methods used in this thesis including how simulation models were developed and research data was generated. Chapter 4 evaluates average network delay from the simulation model to compare different connected vehicle traffic scenarios. Chapter 5 is an economic evaluation of the pay for priority policy proposed in this research. Finally, Chapter 6 presents conclusions and recommendations based on the research outcomes.

CHAPTER TWO

LITERATURE REVIEW

The first section of this chapter (Section 2.1) reviews various studies that have used connected vehicle technology to manage traffic at signalized intersections. The second section (Section 2.2) examines recent research into market-inspired intersection control strategies. The next section, (Section 2.3) explores the public opinion concerning charging drivers for use of the transportation system while using the studies reviewed in section 2.2 as examples. The final section (Section 2.4) identifies the expected cost to equip signalized intersections with V2I technology.

2.1 Utilizing Connected Vehicle Technology to Increase Efficiency at Signalized Intersections

An early study on the utilization of CVT at intersections was introduced by Gradinescu et al. in 2007 which suggested calculating demand through communication with vehicles within a few miles of an intersection to calculate optimum cycle length and phase splits at the beginning of each cycle (Gradinescu et al. 2007). A similar approach was used by Wang et al. in 2013 (Wang et al. 2013). Both studies concluded that with 100% connected vehicle penetration this method resulted in reduced vehicle delay and therefore more efficient intersection operation. These method uses many of the same theories used to calculate pre-timed signal plans and uses real-time data to run these calculations each cycle however it requires substantial data processing power to work as quickly as necessary. A different approach would be to use only a subset of vehicle data to determine optimum signal timing. For example, Kari et al. developed an algorithm that uses only queue length information available from communication with vehicles and resulted in up to 61% reduction in travel time and 32% reduction in system wide fuel use (Kari et al. 2014).

All studies discussed so far have assumed 100% connected vehicle penetration level. However, this is an unrealistic assumption in the near term because a complete turnover of the US vehicle fleet once vehicle communication technology becomes a requirement would take 15 or more years (Information Handling Services 2014). Therefore it is important to determine at what penetration level connected vehicles would be useful to increase intersection efficiency. In 2009 a study was published that varied the penetration level of connected vehicles in an urban network with 9 signalized intersections and concluded that 33% penetration was the critical value where utilizing connected vehicle information led to a more efficient intersection than existing conditions. (Priemer and Friedrich 2009).

Many existing studies that attempt to demonstrate the benefits of CVT at intersections compare their algorithms to pre-timed signal plans which are notoriously inefficient compared to other signal designs. A more fair assessment of the benefits of information from connected vehicles would be to compare a scenario utilizing connected vehicle data to an actuated or adaptive signal timing plan. Goodall compared his algorithm to minimize vehicle delay along a corridor of four signalized intersections to a base scenario of Synchro coordinated actuated signal plans (Goodall 2013). Goodall came to a similar conclusion as previous study and found that as few as 25% of vehicles would need to be equipped with CVT for his algorithm to outperform the baseline timing plans.

Another consideration that is not addressed often in literature on this topic is that the transportation network is a multimodal system. He et al. proposed a mixed integer linear program designed to minimize multimodal delay (He et al. 2012). The simulation, which accounted for passenger cars and transit vehicles, compared their algorithm with Synchro optimized actuated coordinated timing plans and found that multimodal delay could be reduced as much as 8% along the 8 intersection corridor. This study also varied connected vehicle penetration and found the critical connected vehicle penetration was 40%. A more recent study by the same authors suggests allowing only priority eligible modes (pedestrians, transit, and emergency vehicles) to request priority at an intersection while passenger cars must rely on standard signal actuation (He et al. 2014). This method is essentially an expansion of existing transit signal priority operation and is meant to solve the issue of connected vehicle market penetration. The simulation results showed that transit and pedestrian delay was reduced by 25.9% and 14% respectively without having a significant impact on passenger car delay.

Connected vehicle technology will undoubtedly make an impact on intersection efficiency in the near future. Similarly the development of a fully autonomous vehicle with CVT will have a significant impact. Many companies, like Google and BMW, are working toward building an autonomous vehicle that can be sold to the public therefore it is important to look at the impact that automation may have on increasing efficiency at intersections in the future. One of the earliest attempts to create autonomous-like control at intersections using emerging connected vehicle technology analyzed the possibility of combining cooperative adaptive cruise control, new technologies coming out of the IntelliDrive program, and smart traffic signals to adjust signal timings in real time to improve mobility (Malakorn and Byungkyu Park 2010). This study predicted that these types of systems could reduce delay as much as 91% while also reducing fuel use by 75%.

Jin et al. has suggested that vehicles with automation capabilities will be able to use feedback from signal controllers to adjust vehicle trajectory to minimize emissions and fuel consumption (Jin et al. 2012a). The simulation results in this study showed a 94% reduction in CO_2 emissions. This is an important study because it suggests that autonomous vehicles will be able to take advantage of the communication capabilities of intersections above and beyond what a normal connected vehicle would be able to without having to wait for full market penetration of autonomous vehicles.

There have been a few studies that have imagined a future without traffic signals at all. In this scenario all vehicles on the road would be fully automated and use CVT to communicate with a controller at each intersection to adjust vehicle trajectory and avoid collisions with crossing traffic without the use of conventional traffic signals. Jin et al. simulated this theory at an isolated intersection and observed up to 60% reduction in stops which resulted in a 58% reduction in travel time variability (Jin et al. 2012b). Lee and Park conducted a similar study at an isolated intersection and observed a 99% reduction in stop delay at the intersection (Lee and Park 2012). In a follow up study Lee et al. wanted to quantify the environmental impacts of such a drastic change along a four intersection corridor (Lee et al. 2013). The study found that delay time was reduced as much as 100% and resulted in reduced travel time as well as up to 36% reduction in CO_2 emissions and up to 37% fuel savings.

2.2 Market-Based Strategies for Intersection Control

Some researchers are focusing on non-traditional means of controlling intersections in the age of connected vehicles. For example, market-inspired intersection control would accept payment at intersections and disburse priority based on the amount paid. In 2012, Vasirani and Ossowski published research that utilizes a market-based approach to intersection control by requiring travelers pay to reserve a specific time at a signal for them to move through the intersection (Vasirani and Ossowski 2012). The initial price of a time slot is set by an intersection manager and is based on demand at that intersection. If a specific time slot has multiple reservations travelers will be able to bid for the disputed slot. The algorithm proposed in this study rewards the traveler who values their time the most with less delay at the intersection. However, this is not an inherently fair method to determine signal timing because simulation shows that while delay decreases for winning bidders, overall delay at the intersection increases. Furthermore, in a network of intersections if a traveler is unable or unwilling to pay the minimum price for a reservation that vehicle is forced to choose another route with less expensive minimum payments.

A study published soon after the previously discussed article took a similar approach to intersection control except that it allows “free-riders” who do not make bids at any intersections as well as travelers who will not make a bid if the minimum price is above their predesignated limit (Carlino et al. 2013). In this case, instead of forcing travelers who do not wish to pay to choose a different route the intersection system will reward travelers who wait in a long queue or choose a lane with a short queue so that no one will have to wait indefinitely to be served. The researchers tested this algorithm on street networks in four major U.S. cities and found that system travel times decreased in three of the four cities when compared to a FIFO intersection control strategy. However, there was no comparison of travel time for bidders versus non-bidders or winners versus losers.

Another researcher took yet another slightly different approach to market-based intersection control. In his dissertation Isukapati proposes requiring a base initial fee from all drivers, regardless of demand at the intersection, and then allowing drivers to contribute more money based on their perceived value of time (Isukapati 2014). Additionally, instead of granting individual vehicles permission to move through the intersection, like the previous market-based studies, in this scenario all vehicles for a specific movement are grouped together and each movement is competing for the right to move through the intersection. This method also takes metrics like queue length and time since last green indication into account when determining the “winner.” This strategy was simulated with an intersection of a high volume and low volume road and compared to actuated control. The overall intersection delay did not change significantly between the market-based control and actuated control, however delay was more evenly distributed between the high volume approach, which experienced longer delays during actuated control, and the low volume approach, which experienced much shorter delay during actuated control. Additionally, travelers who valued their time more were found to pay higher amounts at the intersection but experienced similar quality of service to those who did not pay extra.

2.3 Public Perception on Different Pay for Priority Strategies

Any change in the status quo of transportation finance is inevitably met with a surge of public interest and often public opposition. In a recent study about public opinion on congestion pricing one of the two specific factors that were found to have the most influence people's perception of congestion pricing was the driver's ability to choose (Swanson and Hampton 2013). The same study also found that the "fairness" of a pricing proposal was an important factor to consider. Another study released by the FHWA that gauged public opinion with regards to tolls and road pricing concluded that some of the factors necessary to bolster positive public opinion for a user fee transportation project include equity and fairness for users as well as simplicity (Zmud Johanna and Arce 2008).

The three market-based intersection control strategies described in section 2.2 take very different approaches to the level of freedom a traveler has to choose. In all cases travelers are given the choice to decrease their delay at an intersection by paying more than the travelers around them. On the other hand, only Carlino et al. allow travelers a choice of whether or not they wish to pay at all. Isukapati suggests requiring an initial fee for all travelers based on the operating cost of the system and thus does not change over short time periods. Vasirani and Ossowski's intersection control proposal restricts traveler's choices the most because the minimum payment required at an intersection is in constant flux based on the demand at that intersection and requiring travelers to win a bid before being allowed to enter the intersection. This method makes it difficult for travelers to plan their route and travel time due to uncertainty of traffic conditions on their desired route.

The perceived fairness of a policy can refer to a number of factors. The most common concern when discussing the fairness is how the policy will affect low income individuals. The policies suggested by Vasirani & Ossowski and Isukapati will raise the financial cost of driving for all travelers because they require payment to use the intersection. Additionally, Vasirani and Ossowski presented data that proves that individuals who are not willing or able to pay the minimum bid or pay to compete for the most desirable time slots will experience increased delay (Vasirani and Ossowski 2012). The researchers justify this finding in their research by claiming their policy will promote system equilibrium. While the policy proposed by Carlino et al. does not require travelers to pay at an intersection the article does not provide enough data to determine if those not paying at the intersection are negatively affected in the form of increased delay. However, the researchers recognize that even if individuals who cannot pay are not negatively affected, they still will not be able to experience the positive aspects of the system either. In order to combat this perceived unfairness the researchers propose a system that grants a fixed number of credits to drivers to use at intersections which is renewed on a weekly or monthly basis (Carlino et al. 2013). This approach will level the playing field for all travelers and encourage prudent use of their limited credits.

The pricing structure of the three market-based intersection control strategies is a good representation of varying levels of simplicity for pay for priority policies. The policy proposed by Carlino et al. is the most complex of the three because it utilizes a complex algorithm that supplements user bids with other factors like queue length and time since last green. Additionally there are several payment options including no payment, static payment which will only bid a predetermined amount, and a fair payment method which spreads predetermined budget for trip out over all signalized intersections on the route (Carlino et al. 2013). This system is very different from any system currently used for road traffic and make it difficult to garner positive public opinion without tangible examples and user experience to back up the policy (Zmud Johanna and Arce 2008). The policy proposed by Vasirani and Ossowski is the middle of the road policy in terms of simplicity. The model is relatively simple, pay the minimum bid plus more if you wish to decrease your delay, however the mechanics behind the varying minimum bid may elude some of the public. Fortunately, this method is similar to congestion pricing on freeways which is becoming more prevalent throughout the country. Finally, Isukapati's proposal that requires a fixed minimum payment plus more to decrease delay is the most simple policy for the public to grasp. It is similar to the structure of toll roads in that the initial fee is fixed and the public will generally understand the concept of paying more money to decrease delay.

2.4 System Cost for Signal Priority System

The cost to implement a priority payment system has yet to be thoroughly researched. The USDOT has developed a cost estimation tool, called co-pilot, to assist agencies with budgeting a pilot program. According to a co-pilot analysis the cost of an intelligent traffic signal system without the inclusion of new loop detectors, which are already present on the corridor being studied for this research, suggests that the system would cost about $12,000 per intersection (USDOT 2015).

Transit signal priority (TSP) is a similar system that is widely adapted across the country and may be able to provide a good range of cost estimates. A recent study by the transit cooperative research program estimates that the cost of implementing a TSP system can vary greatly, between $5000 and $30,000 per intersection, depending on the type of detection system used and if the intersection is in need of any upgrades to support the system (Danaher 2010). Similar ranges have been estimated in previous studies of TSP implementation cost research (Smith et al. 2005; Baker et al. 2002)

Nearly all of the studies reviewed have ignored the cost of supporting connected vehicle technology at a signalized intersection. Isukapati suggested in his research that money collected at each intersection controlled by a market-based system may be used to cover the cost of infrastructure and operations (Isukapati 2014).

2.5 Summary of Literature Review

Many researchers have developed algorithms to utilize information available through connected vehicle technology to increase efficiency at signalized intersections.

While some studies only researched affects when connected vehicle penetration was at 100% penetration as low as 25% has been shown to decrease overall intersection delay. Another approach that will undoubtedly utilize connected vehicle technology is market-based approaches to intersection control. Three different proposed policies were reviewed which showcased a wide range of policy options and levels of success at reducing delay at signalized intersections. The main difference between the research reviewed in section 2.1 and section 2.2 is that in section 2.1 use of data from connected vehicles benefited all users equally while in section 2.2 users who were able and chose to spend the most money generally experienced less delay than travelers who did not spend extra.

The market-based intersection control policies were compared based on research on how the public perceives transportation fees. Research has shown that the public values choice, fairness, and simplicity while also gravitating towards policies they have seen before or that are similar to methods already in use. Each market-based control policy had pros and cons based on this criteria and there was no clear “best” policy based on public perception.

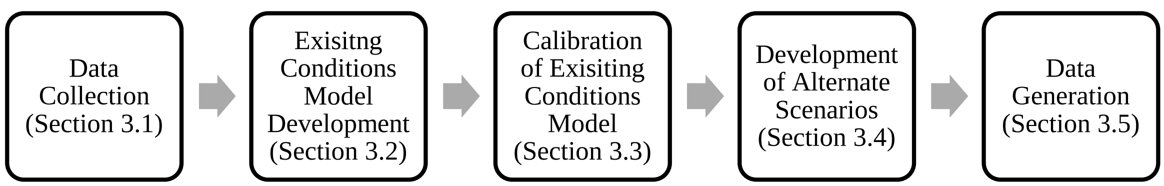
Finally, there is limited literature about the expected cost of an intelligent signalized intersection like the one evaluated in this research. The most similar system that has experienced widespread adoption are transit signal priority systems, the cost of which range from $5,000 to $30,000 per intersection. This research evaluated revenue stream of a signal priority system for connected vehicles at intersections in an attempt to offset the costs of the system while also decreasing delay for all travelers in the network.

CHAPTER THREE

RESEARCH METHOD

This research examines the use of connected vehicle technology to increase efficiency at signalized intersection in a mixed traffic environment. This will be done by creating a micro-simulation model of a corridor in Clemson, SC using traffic volume, geometry, signal timing, and travel time data collected from the field. The calibrated model will then be used to evaluate several alternate traffic scenarios with different connected vehicle penetration levels. This research will analyze the affect that allowing connected vehicles to request priority has on non-connected vehicles using a similar simulation strategy. The steps shown in Figure 3.1 were used to create and generate output from each scenario and are discussed throughout the rest of this chapter.

Figure 3.1 – Model Development and Data Generation Process



3.1 Data Collection

The transportation network used in this research consists of two main corridors in Clemson, SC, SC 93/Old Greenville Highway and SC 133/College Avenue surrounding Clemson University main campus. These two corridors meet at a busy intersection in the Clemson downtown (Figure 3.2). The study area extends about 1 mile in each direction away from the intersection and includes 8 signalized intersections and 11 unsignalized intersections which are stop-controlled on the minor streets. Figure 3.2 shows an aerial snapshot of the network to be studied and identifies the name and location of each intersection.

The time period that will be studied in this research is the peak afternoon hours from 4:00 PM to 6:00 PM. Vehicle volume and turning movement data was manually collected with the assistance of JAMAR traffic count boards at each of these intersections over the course of the spring 2015 semester. JAMAR traffic count boards were set to 5 minute intervals so that the change in volume over time could be observed to incorporate into the model. Data was only collected on Tuesdays and Thursdays to avoid any interference the beginning and end of the work week may have on traffic data. Finally, data was only collected on “normal” school days, meaning if the school was closed due to extreme weather or a scheduled holiday data was not collected on that day. The vehicle volume and turning movement raw data that was collected can be found in Appendix A.

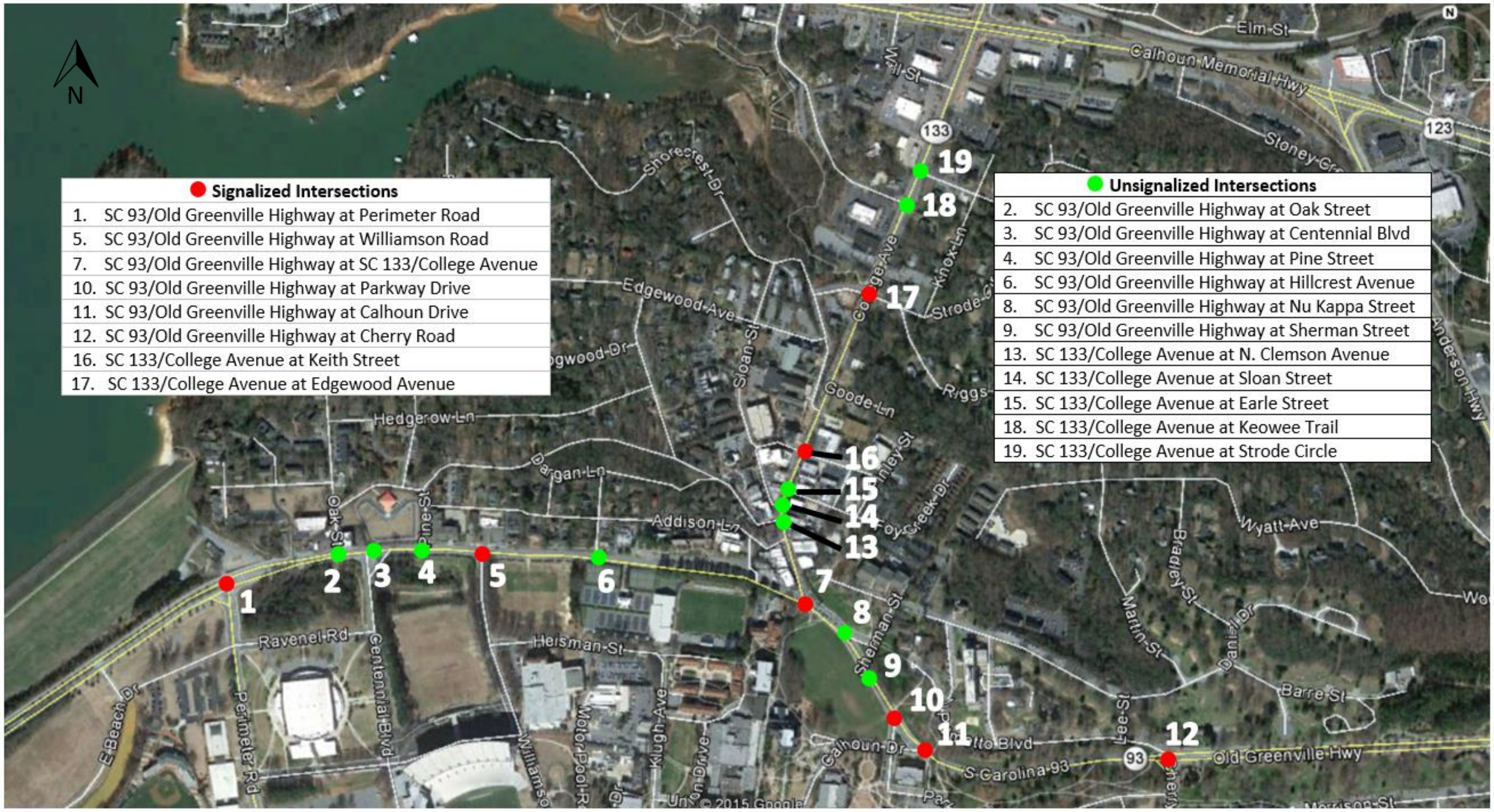


Figure 3.2 – Study Network and List of Intersections

Field data for travel time was collected between 4:00 and 6:30 on Thursday, May 22, 2015. The smart phone application "MapMyRide" was used to collect data for each run (MapMyRide, 2015). This application is meant to be used by bicyclists to record the route, travel time, speed, and other metrics of a bicycle workout. Each recorded workout can be accessed at a later time on a personal computer via the company's website at mapmyride.com. Utilizing this application allowed the driver to start a workout from a safe location off the roadway then drive a designated route before again pulling over to a safe location to stop and save the data. This tool was used to collect data for 6 routes on US 93 and College Avenue and then process the data to find the travel times from exact locations using the internet interface and MS Excel software.

The sample size of travel times to be collected for each corridor was determined following the procedure outlined in chapter 3 of the ITE Transportation Planning Handbook (Anderson Bomar 2009). The equation $N = Z_{\alpha}^{2}\frac{(CV)^{2}}{e^{2}}$ was used to calculate the sample size needed to obtain data with a 95% confidence interval and an error of 10%. In this equation, N is the sample size to be collected, Z is the normal standard variate based on a desired confidence level of (1-α), CV is the coefficient of variation, and e is the specified relative error. A coefficient of variation of 10% was chosen from the Transportation Planning Handbook to calculate sample size based on the largest AADT along these segments of roadway, about 15,000 vehicles per day (SCDOT, 2015). The resulting sample size rounded up to 6 samples per corridor. This estimation is similar to another source in literature that suggests a sample size of 8 for an arterial street with 3-6 traffic signals per mile and a desired confidence interval of 95% with a 10% error (Turner et al. 1998). A sample size of 8 was decided on because both sample size estimates were easily attainable and a slightly larger sample size was considered desirable for this research.

3.2 Existing Condition Model Development in VISSIM

The microsimulation software VISSIM was chosen for this research because it can support signal priority requests using the ring barrier controller add-on. The "VISSIM Quick Start Checklist" from the user manual was used as a guide to build the study network from scratch (PTV Planung Transport Verkehr AG 2012). After importing and scaling the background image, the first step was to create default speed distributions. The default speed distributions in VISSIM, which are in km/hr, were modified to represent speed distributions needed for this network in mi/hr. Speed limits that occur within the study network include 15 mph, 25 mph, 35 mph, and 40 mph.

The next step was to check vehicle types and classes. A new field was created, called "CV" for connected vehicles. While there are no connected vehicles in the existing/base scenario, CV scenarios are defined in the initial model development process to facilitate creation of alternate scenarios after calibration. The CV vehicle type and class is a replica of the "car" type and class with a different label to distinguish between regular and connected vehicles at intersections and for priority requests. After ensuring the vehicle types and classes were all correct, the vehicle compositions had to be specified. The default composition is 98% cars and an assumed 2% heavy vehicle. At this time the vehicle composition for the connected vehicle scenarios was also created. Table 3.1 lists the composition for each scenario.

Table 3.1 – VISSIM Vehicle Compositions

Composition Name	Car	CV	HV
Default	98%	0%	2%
10 Percent	88%	10%	2%
20 Percent	78%	20%	2%
30 Percent	68%	30%	2%
40 Percent	58%	40%	2%
50 Percent	48%	50%	2%
60 Percent	38%	60%	2%
70 Percent	28%	70%	2%
80 Percent	18%	80%	2%
90 Percent	8%	90%	2%
100 Percent	0%	98%	2%

After the initial file set up the links and connectors were overlaid on the background image to create the base network. Vehicle inputs were placed at network endpoints in terms of vehicles per hour (vph) for each 15 minute interval, the sum of three 5 minute intervals counted in the field. A 10 minute warm-up period was used at the beginning of the simulation using vehicle inputs that were 75% of the average measured flow. Routing decisions were placed at each intersection and the total flow for each movement was used to assign turning movement percentages on each approach to an intersection. After all routing decisions were created it was noted that the routing decision point on 133 NB between N. Clemson Rd. and Sloan St. were very close together due to the intersection geometry. For this situation the route before Sloan St. and all routes on the approaches at the intersection of 133 and N. Clemson Rd. were combined to create a continuous routing decision through the tight intersections (Intersections 13 and 14 in Figure 3.2).

The rest of the network development involved setting up traffic control regulations for the vehicles on the network. Desired speed decisions were added at vehicle inputs and where speed limits changed to match posted speed limits. Reduced speed zones were added at sharp turns at intersections to account for the slowing down of vehicles over a short distance. Stop signs were added and conflict areas defined at unsignalized intersections. Finally, ring barrier control (RBC) signal controllers were created for each intersection with the exception of Parkway Dr. and Calhoun Dr. (Intersections 10 and 11 in Figure 3.2) which used the same signal controller. Signal heads and detectors corresponding to the appropriate signal controller were added and conflict areas were defined for permissive left turns and right turn on red situations.

Appendix B presents the signal timing plans procured from SCDOT and the City of Clemson to generate the RBC signal timing plans used in VISSIM and as a base for Synchro models, discussed in Section 3.4.

Appendix C contains a screenshot of the entire VISSIM network and close up screenshots of each signalized intersection to detail signal head, detector, and stop sign placement. The RBC signal timing plans used at each intersection is also included.

3.3 Calibration of Existing Condition Model

To calibrate the existing model several types of traffic data had to be collected. Nodes were created around each signalized intersection and the output file was configured to determine the volume of vehicles making each movement at the intersection every 15 minutes to allow for comparison to field volumes collected. Six travel time segments were created which corresponded to segments evaluated in the field and the simulation output file was configured to calculate the average travel time over the 2 hour simulation period.

Before the model could be declared calibrated the average travel time and vehicle volumes from 8 simulation runs had to closely match the field observations (10%). Initial travel times were off for some routes. Changes made to make the model match field observations include increasing the speed allowed in some reduced speed zones, shortening the length of or eliminating some reduced speed zones, adjusting the placement of speed decisions, and finally making slight adjustments to the desired speed distributions used for the model. The results of the field travel time analysis as well as the final travel times of the calibrated model can be seen in Table 3.2. The fact that the average travel time for each route in the calibrated VISSIM model is within the 95% confidence interval (CI) based on the field tests verifies that the model is calibrated.

While the model was being calibrated by travel time it was also being checked to ensure the correct volume for each movement at signalized intersections using the node output information. After the initial run, two routing decision errors were found and corrected which helped account for some of the travel time discrepancies. The vehicle volumes for all movements at signalized intersections were found to be within ±10% of the observed field volumes.

Table 3.2 – Travel Time Analysis for Model Calibration

	Travel Time [s]					
	Route 1	**Route 2**	**Route 3**	**Route 4**	**Route 5**	**Route 6**
Field Run 1	116	99	125	89	129	94
Field Run 2	91	84	140	89	117	171
Field Run 3	86	90	106	100	73	110
Field Run 4	163	83	123	133	124	101
Field Run 5	129	89	160	90	114	182
Field Run 6	153	98	124	79	191	110
Field Run 7	73	84	160	90	131	90
Field Run 8	131	94	136	82	93	118
Field Average	117.8	90.1	134.3	94.0	121.5	122.0
Standard Deviation	32.3	6.4	18.8	16.9	34.3	35.0
-95% CI	95.3	85.7	121.2	82.3	97.7	97.8
+ 95% CI	140.2	94.5	147.3	105.7	145.3	146.2
Calibrated VISSIM Average	137.6	88.4	134.5	97.1	110.2	141.5

3.4 Development of Alternate Scenarios

Once the existing condition model was calibrated the alternate scenarios defined two scenarios were developed as variations on the existing condition model to compare the results from the CV simulation with. In the first of these cases signalized intersections were optimized individually, isolated from other intersections, in Synchro. The second case uses optimized and coordinated signal timings generated in Synchro to model the system as a coordinated network of traffic signals. This was accomplished by creating the same study network in Synchro as was created in VISSIM. The software Sychro 9 was chosen for this task because it is the standard software used in industry for traffic signal operations and optimization. After the existing conditions network was created the file was copied and modified for the “isolated optimized scenario” and the “coordinated scenario.” For the isolated optimized scenario, each signal was optimized individually used the “optimize cycle length” command followed by the “optimize splits” command. The coordinated scenario was created following the procedure described in chapter 17, Signal Optimization Routine, in the Synchro 9 user manual (Trafficware 2014). In the “optimize network cycle lengths” command Sychro was directed to analyze cycle lengths between 50 seconds and 160 seconds at 5 second increments, uncoordinated intersection were allowed rarely, and the extensive offset optimization analysis was selected. All other variables were default. Synchro chose 126 seconds as the optimal cycle length with some lower volume intersections operating at a half cycle length of 63 seconds. While a 5 second increment has been specified for cycle length analysis, Synchro automatically added 1 second to the analyzed cycle length when it was an odd number because only even cycle lengths were allowed. The next step was to “optimize network offsets” which also optimized splits at each intersection. A step size of 1 second was used to optimize offsets.

After the new signal timing plans for the isolated optimized and coordinated scenarios were generated, the RBC timing plans in the corresponding VISSIM files were updated to match these timings. Appendix D contains the Sychro reports generated for the isolated optimized scenario and the coordinated scenario, each of which only contains reports about signalized intersections. The isolated optimized scenario resulted in the best network performance and was used for all alternative scenarios that include connected vehicles to ensure that any improvement in system performance did not include improvements that could be made by simply retiming the existing signal system.

Three priority direction scenarios were created to be studied. The first scenario allowed priority to be requested by CV from all directions at a signalized intersection. The second scenario only allowed vehicles traveling on US 93 or College Avenue to request priority. The third scenario reduced the permissions further to only allow CV traveling in the main direction of travel, determined by volume, on US 93 and College Avenue. For the third scenario directions that were allowed to request priority include East to West on US 93 from the Eastern beginning of the network to the US 93/College Avenue intersection, West to East on US 93 from the Western beginning of the network to the US 93/College Avenue intersection, and South to North on College Avenue from the US 93/College Avenue intersection to the Northern end of the network.

For these scenarios all directions allowed to request priority have the same relative priority and the priority mode was set as "early/extend" which allows for early return or extension of the priority signal group. The extend limit was determined by allocating 20% of the cycle length proportionally to phases serving vehicle movements at a signal. The 20% of cycle length is based on an observation noted in literature that a change in the cycle length as much as 20% does not cause significant delay to competing movements (Smith et al. 2005). All check-in detectors were placed 600 feet behind the stop bar on major streets and 300 feet behind the stop bar on minor streets, the only exception is in cases where another intersection is less than 600 feet away from the signalized intersection, in that case check in detectors were placed immediately downstream of the adjacent intersection so that only vehicles traveling to the signalized intersection would be considered. The travel time was calculated using the distance and speed limit of the approaches. Check-out detectors were placed immediately past the stop bar for all movements. Detectors used to activate the TSP function were set to only detect the "CV" class of vehicles as transit vehicles. Appendix E contains screenshots of signalized intersections that includes check-in and check-out detector placement as well as the RBC signal timings plans used for each intersection where priority was allowed to be requested in only one direction on the major streets.

3.5 Research Data Generation

Each scenario created in VISSIM was run 8 times, based the results of the statistical sampling formula mentioned in Section 3.1, for each CV penetration level defined in Table 3.1 with different seed numbers to calculate average travel time at defined travel time segments and delay at intersections. The multi-run function in VISSIM was used to run the simulation. A random number generator was used to pick a starting seed and interval number which resulted in the simulation using seeds 14, 46, 78, 110, 142, 174, 206, and 238. Data collected from these runs include the average network delay for all vehicle types, cars only, and connected vehicles only as well as the average green time distribution within a cycle and the total number of connected vehicles that move through each intersection over the 2 hour simulation period. Appendix F contains example VISSIM output files created during each simulation run.

CHAPTER FOUR

OPERATIONAL ANALYSIS

This chapter identifies trends in average delay per vehicle that emerge from the results of simulation studies for each traffic scenario modeled. Findings from simulation outputs are grouped by connected vehicles (CV), non-connected vehicles (non-CV), and all vehicle types combined. The priority permission scenario where CV are allowed to request priority from all directions is referred to as the "all-way" scenario. The priority permission scenarios where CV are only allowed to request priority on the main street are called "two-way" when both directions may request priority and "one-way" when only the direction with the highest volume may request priority.

4.1 Analysis of Non-Connected versus Connected Vehicle Delay

The idea behind allowing CVs to request priority at a signalized intersection is that it will results in decreased delay for CVs when compared to non-CVs. The three simulation models with different CV priority direction permissions in mixed traffic conditions were simulated for CV penetration levels of 10% to 100% at 10% increments.

It was observed that CVs generally experienced less delay than non-CVs, especially at low CV penetration levels. Table 4.1 presents the average delay per vehicle for non-CVs and CVs for the all-way priority request scenario, and graphically presented in Figure 4.1.

Table 4.1 – Average Delay per Vehicle for Non-Connected and Connected Vehicles (All-Way Scenario)

% CV	Non-CV Delay [s]	CV Delay [s]
10%	55.54	52.41
20%	57.38	56.50
30%	60.54	59.60
40%	61.13	61.09
50%	61.33	61.44
60%	64.00	64.05
70%	63.95	64.21
80%	64.04	64.08
90%	66.55	66.77
100%	-	64.52

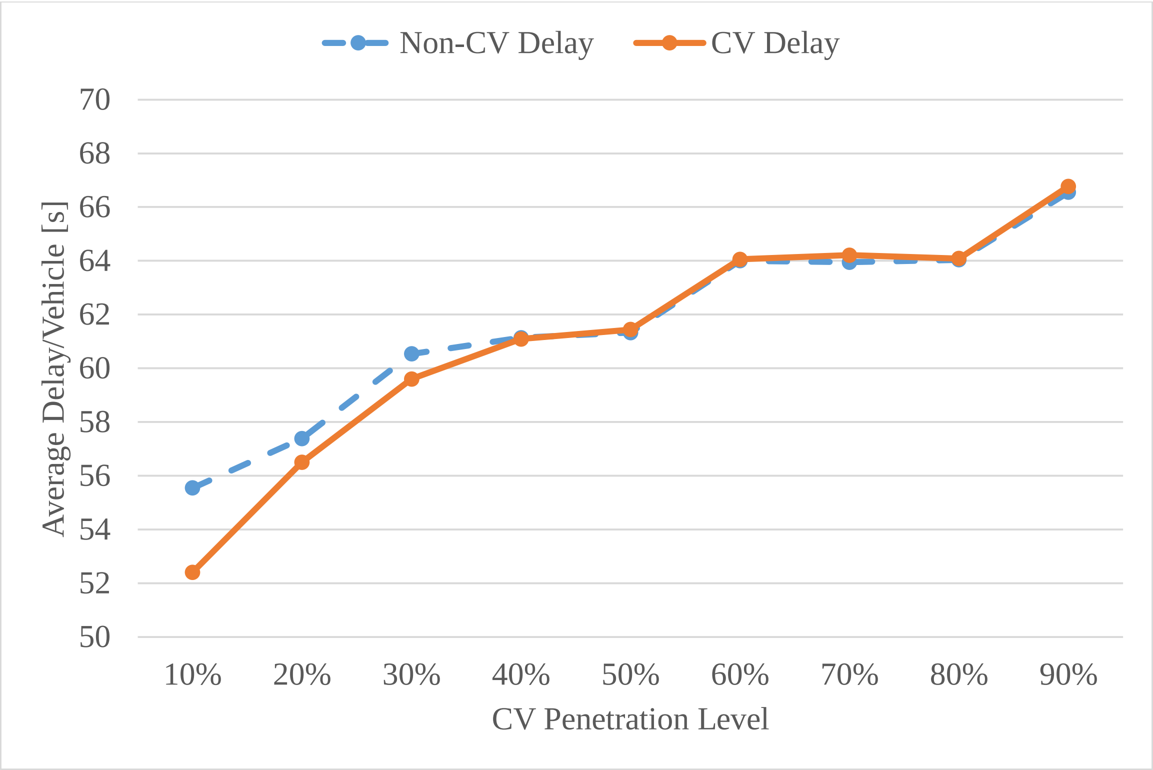


Figure 4.1 – Average Delay per Vehicle for Non-Connected and Connected Vehicles (All-Way Scenario)

A statistical analysis was conducted to determine if the difference in delay is statistically significant between reductions in CVs delay compared to non-CVs. The results of this statistical significance test can be seen in Table 4.2. Assuming that α=0.05 the difference in delay is statistically significant up to 20% CV penetration levels. This analysis is similar to results found by Isukapati, who proposed a pay for priority method at signalized intersections, mentioned in Section 2.2 (Isukapati 2014). He found that drivers who paid higher amount at a signalized intersection to gain priority experienced similar level of service to those who did not pay extra and that is true for most of the CV penetration levels studied for this scenario.

Table 4.2 – Statistical Analysis of Difference in Delay between Non-Connected and Connected Vehicles (All-Way Scenario)

% CV	**Average Difference [s]**	**St. Dev. of Difference [s]**	t_{obs}	**p-value**
10%	-3.14	1.96	-4.51	0.001
20%	-0.88	0.83	-2.99	0.01
30%	-0.94	1.91	-1.39	0.10
40%	-0.05	1.44	-0.09	0.46
50%	0.11	1.66	0.20	0.57
60%	0.05	1.19	0.13	0.55
70%	0.26	1.08	0.69	0.74
80%	0.05	1.88	0.07	0.53
90%	0.23	1.19	0.54	0.70

Table 4.3 presents the average delay per vehicle for non-CVs and CVs for the two-way priority request scenario, and graphically presented in Figure 4.2.

Table 4.3 – Average Delay per Vehicle for Non-Connected and Connected Vehicles

(Two-Way Scenario)

% CV	Non-CV Delay [s]	CV Delay [s]
10%	47.58	43.86
20%	51.70	50.14
30%	53.59	53.05
40%	57.65	57.19
50%	59.41	59.13
60%	60.38	60.38
70%	61.97	61.40
80%	62.20	61.64
90%	62.68	63.28
100%	-	63.87

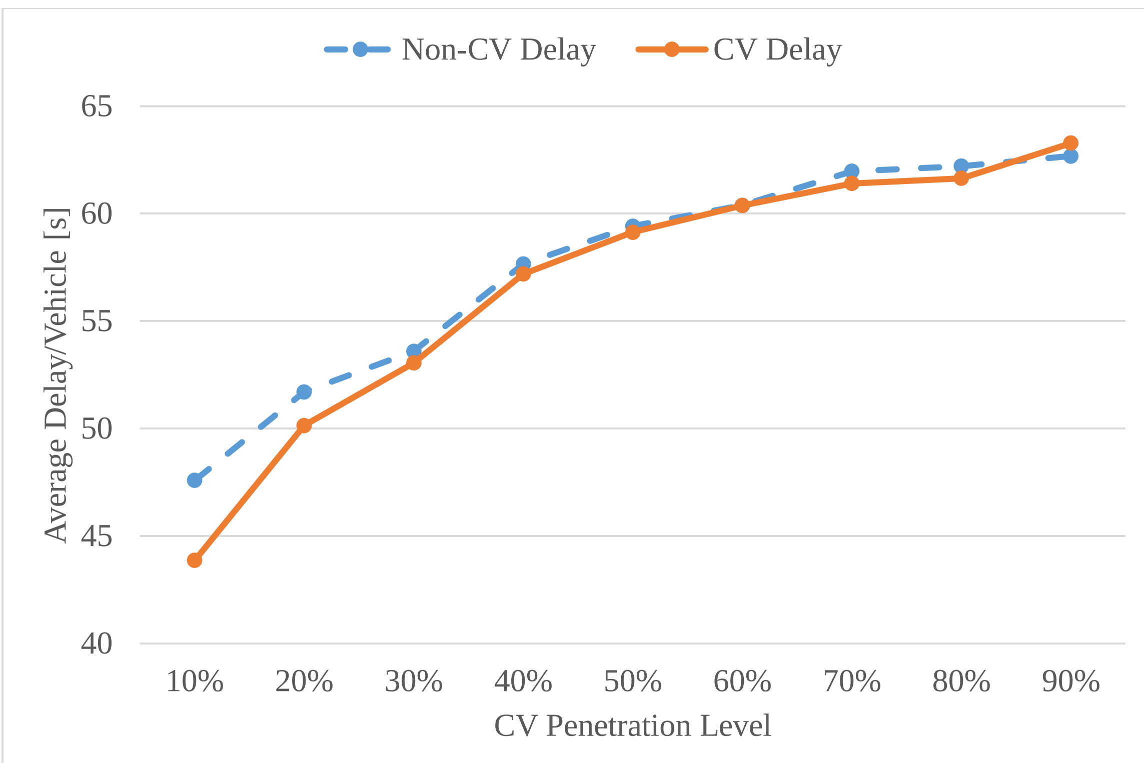


Figure 4.2 – Average Delay per Vehicle for Non-Connected and Connected Vehicles

(Two-Way Scenario)

A statistical analysis was conducted to determine when the difference in delay is statistically significant between reductions in CV delay compared to non-CVs. The results of this statistical significance test can be seen in Table 4.4. Assuming that $\alpha=0.05$ the difference in delay is statistically significant up to 20% CV penetration levels. Even after removing priority requests from the minor streets the resulting difference in delay is similar to the all-way signal priority request scenario. This suggests that it is the conflicting requests made by the traffic flowing opposite the heaviest flow on the main street that is causing the controller to not work as efficiently as possible to serve the CV requests.

Table 4.5 presents the average delay per vehicle for non-CVs and CVs for the one-way priority request scenario, and graphically presented in Figure 4.3.

Table 4.4 – Statistical Analysis of Difference in Delay between Non-Connected and Connected Vehicles (Two-Way Scenario)

% CV	Average Difference [s]	St. Dev. of Difference [s]	t_{obs}	p-value
10%	-3.72	1.39	-7.56	0.0001
20%	-1.56	0.87	-5.05	0.001
30%	-0.54	1.27	-1.20	0.13
40%	-0.47	1.05	-1.26	0.12
50%	-0.28	1.86	-0.43	0.34
60%	-0.01	1.94	-0.01	0.50
70%	-0.57	1.60	-1.00	0.17
80%	-0.57	1.97	-0.81	0.22
90%	0.60	1.86	0.91	0.80

Table 4.5 – Average Delay per Vehicle for Non-Connected and Connected Vehicles

(One-Way Scenario)

% CV	**Non-CV Delay [s]**	**CV Delay [s]**
10%	42.06	38.62
20%	42.38	40.68
30%	42.62	41.44
40%	43.94	42.85
50%	45.14	44.55
60%	47.73	47.82
70%	47.93	48.08
80%	48.77	49.34
90%	50.54	50.21
100%	-	50.27

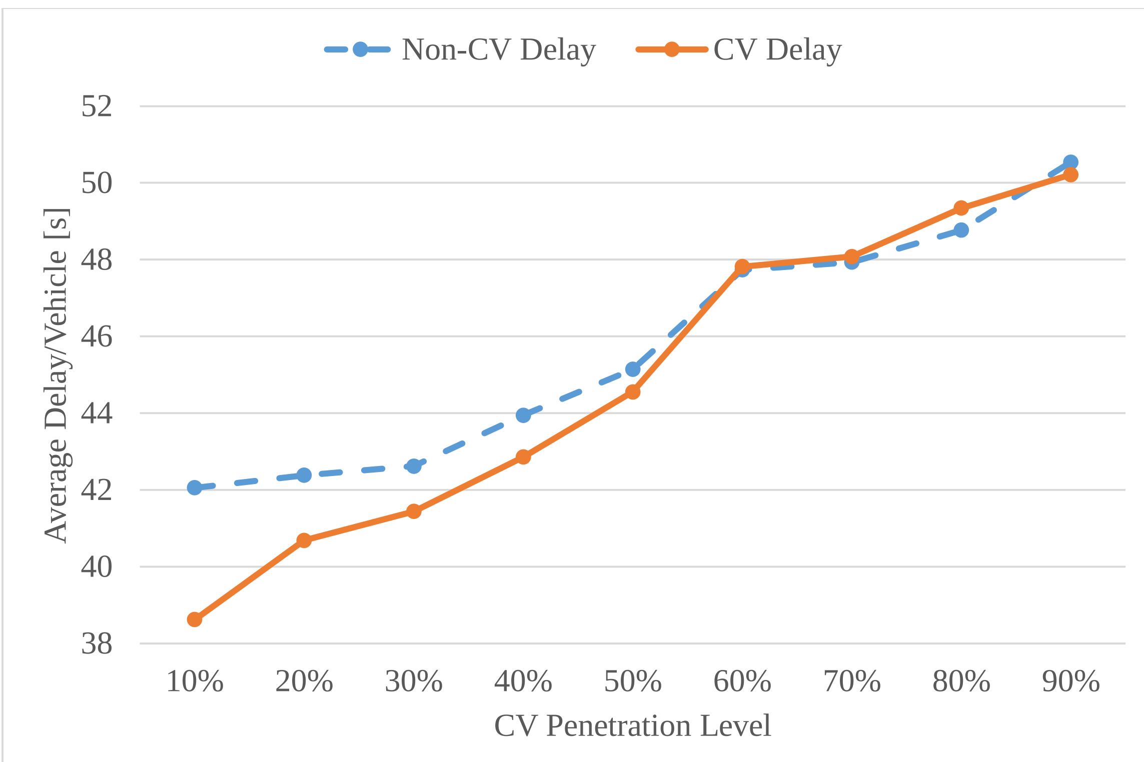


Figure 4.3 – Average Delay per Vehicle for Non-Connected and Connected Vehicles

(One-Way Scenario)

A statistical analysis was conducted to determine when the difference in delay is statistically significant between reductions in CV delay compared to non-CVs. The results of this statistical significance test can be seen in Table 4.6. Assuming that $\alpha=0.05$ the difference in delay is statistically significant up to 40% CV penetration levels. This is likely the best outcome that can be achieved on this network because priority requests from competing directions are not allowed in the one-way scenario. The reason CV do not always experience less delay than non-CVs at higher penetration levels (>40%) is because the controller is not allowed to infinitely extend the green time to accommodate all priority requests in the major direction.

Table 4.6 – Statistical Analysis of Difference in Delay between Non-Connected and Connected Vehicles (One-Way Scenario)

% CV	Average Difference [s]	St. Dev. of Difference [s]	t_{obs}	p-value
10%	-3.44	1.38	-7.05	0.0001
20%	-1.70	0.92	-5.21	0.001
30%	-1.18	0.85	-3.93	0.003
40%	-1.09	0.73	-4.23	0.002
50%	-0.59	1.07	-1.56	0.08
60%	0.08	1.65	0.14	0.56
70%	0.15	1.36	0.30	0.61
80%	0.57	1.52	1.07	0.84
90%	-0.33	1.03	-0.90	0.20

4.2 Analysis of Delay for All Vehicle Types

The average delay per vehicle for all vehicle types on the network was studied for CV penetration levels of 0% (optimized timing conditions) to 100% at 10% increments. The average delay per vehicle is shown in Table 4.7 and graphically illustrated in Figure 4.4. The results of comparing the average delay per vehicle for each priority permission scenario with the optimized conditions delay without CV shows that the best solution in terms of delay for all vehicles is the one-way scenario. A statistical analysis was performed to compare the difference in average delay per vehicle for the one-way scenario to the optimized conditions. The results of this analysis can be seen in Table 4.8. Assuming a confidence interval of 95% (α=0.05), the average delay per vehicle is significantly lower for all CV penetration levels up to 50%.

Table 4.7 – Average Delay per Vehicle for All Vehicle Types

% CV	Sceanrio		
	All-Way Delay [s]	**Two-Way Delay [s]**	**One-Way Delay [s]**
10%	55.37	47.28	41.83
20%	57.31	51.49	42.15
30%	60.33	53.54	42.37
40%	61.21	57.55	43.61
50%	61.48	59.35	44.98
60%	64.11	60.46	47.90
70%	64.22	61.65	48.17
80%	64.16	61.79	49.37
90%	66.82	63.31	50.37
100%	64.63	63.95	50.42

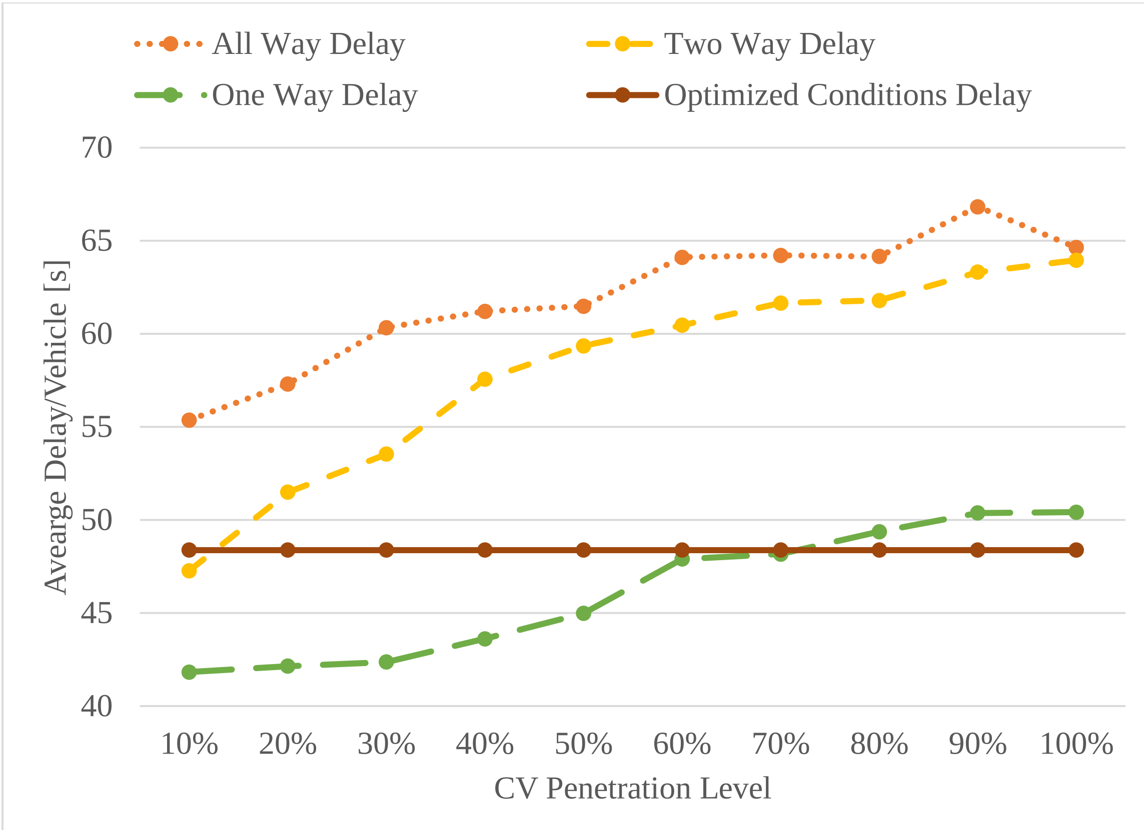


Figure 4.4 – Average Delay per Vehicle for All Vehicle Types

Table 4.8 – Statistical Analysis of Delay for All Vehicle Types

% CV	Average Difference [s]	St. Dev. of Difference [s]	t_{obs}	p-value
10%	6.55	1.16	15.95	0.0000005
20%	6.23	1.48	11.88	0.000003
30%	6.01	2.19	7.75	0.0001
40%	4.77	2.50	5.40	0.001
50%	3.40	2.89	3.32	0.01
60%	0.48	5.68	0.24	0.41
70%	0.21	6.08	0.10	0.46
80%	-0.99	4.98	-0.56	0.70
90%	-1.99	6.12	-0.92	0.81
100%	-2.04	6.51	-0.89	0.80

This finding, along with the fact that the average delay per vehicle increases as the CV penetration levels increase, resembles the market based approach proposed by Vasirani & Ossowski who found that while connected vehicles experience less delay at a signalized intersection, the overall delay at the intersection is increased (Vasirani and Ossowski 2012). The biggest difference between the finding of Vasirani & Ossowski's research and this research is that there are levels of CV penetration where the network delay is decreased. This is likely due to the fact that the intersections in this study are still controlled by traffic signals which allows non-connected vehicles to be served alongside CVs.

CHAPTER FIVE

BENEFIT-COST ANALYSIS

This chapter considers the scenario where CV traveling in the direction of highest flow on the major corridors (one-way scenario), at different CV penetration levels, are requesting priority at a signalized intersection. The revenue that could be generated by this scale of requests is calculated and compared to the cost of the priority system deployment and maintenance. Another benefit-cost analysis includes the benefit of decreased delay on the network for up to 50% CV perpetration levels. For a project to be considered a viable investment the benefit-cost ratio should be greater than 1.00.

5.1 Revenue Generation

The benefits assessed for the benefit-cost analysis is the revenue generated by allowing CVs to request and receive priority at intersections for the one-way scenario. For the priority request system, revenue is generated by charging CVs that wish to request priority a small fee to do so. A range of fees (low, average, and high) were calculated based on the value of time estimates published by the US DOT and assuming travel time savings of 1 second for the low estimate, 2 seconds for the average estimate, and 4 seconds for the high estimate (US Department of Transportation 2014). This range was chosen because the average delay savings between CV and non-CV when the difference was significantly different (<50% CV penetration) ranged from 1 second to 4 seconds with an average of 2 seconds. The base value used for benefit assessment is

$12.80 per person-hour. This research makes the conservative estimate that there is only one person in each vehicle. The low, average, and high fees to request priority were assumed as follows:

- Low = $0.00356/request
- Average = $0.00711/request
- High = $0.01422/request

Table 5.1 presents the annual revenue from weekday traffic that can be expected for each level of CV penetration across the range of assumed cost per priority request at each intersection. Revenue was calculated by multiplying the number of vehicles requesting priority during the simulated peak hour (i.e., only CV moving through the intersection in the direction of highest flow), with an assumed cost per request. The conservative assumption was made that the 2 hour afternoon peak simulated in this study generates half of daily weekday revenue therefore the peak hour revenue was multiplied by 2 then by 260 (the number of weekdays in a year) to get the results shown in the tables. Table 5.2 combines the revenue at all intersections to present the total expected annual revenue for the network.

A similar approach was used to estimate the benefit of decreased delay per vehicle for all vehicles types on the network. The benefit was only calculated for CV penetration levels up to 50% because there was no significant reduction of network delay past this point. Each CV penetration level had a different range of delay reductions per vehicle based on the simulation results. The range of delay reductions per vehicle used as well as the corresponding monetary benefit per vehicle is shown in Table 5.3. Annual benefit to society due to the reduction of average delay per vehicle was calculated as described in the previous paragraph, by multiplying the benefit per vehicle by the number of vehicles on the network, multiplying that number by 2 to get the daily benefit, then multiplying by the number of weekdays per year, 260. The results of this calculation are shown in Table 5.4. Finally, Table 5.5 shows the total benefit to society when the benefit from revenue generated by priority requests is combined with the benefit due to reduction in average delay per vehicle for all CV penetration levels.

Table 5.1 – Expected Annual Revenue per Intersection Based on Weekday Traffic

Intersection	Charge	Percent of Vehicles Requesting Priority									
		10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
93/Perimeter Rd.	Low	$81	$162	$247	$332	$415	$499	$580	$661	$756	$820
	Average	$162	$324	$494	$663	$829	$999	$1,161	$1,323	$1,511	$1,639
	High	$324	$648	$987	$1,327	$1,658	$1,998	$2,322	$2,646	$3,023	$3,279
93/Williamson Rd.	Low	$147	$288	$441	$588	$746	$884	$1,040	$1,191	$1,342	$1,460
	Average	$294	$577	$882	$1,176	$1,492	$1,768	$2,080	$2,382	$2,683	$2,921
	High	$588	$1,153	$1,764	$2,352	$2,985	$3,535	$4,161	$4,764	$5,367	$5,842
93/College Ave.	Low	$556	$1,114	$1,675	$2,214	$2,768	$3,324	$3,876	$4,436	$4,979	$5,408
	Average	$1,112	$2,227	$3,351	$4,428	$5,536	$6,648	$7,753	$8,872	$9,957	$10,817
	High	$2,224	$4,455	$6,701	$8,857	$11,073	$13,297	$15,505	$17,744	$19,915	$21,633
93/Calhoun Dr.	Low	$49	$494	$720	$974	$1,210	$1,445	$1,688	$1,926	$2,148	$2,348
	Average	$475	$987	$1,440	$1,949	$2,420	$2,891	$3,377	$3,852	$4,297	$4,696
	High	$950	$1,975	$2,879	$3,897	$4,839	$5,781	$6,754	$7,704	$8,593	$9,392
93/Cherry	Low	$198	$407	$601	$818	$1,012	$1,206	$1,402	$1,602	$1,800	$1,969
	Average	$396	$814	$1,202	$1,636	$2,024	$2,412	$2,804	$3,204	$3,599	$3,938
	High	$791	$1,628	$2,405	$3,271	$4,048	$4,824	$5,608	$6,407	$7,199	$7,877
College Ave./Keith St.	Low	$158	$334	$497	$650	$810	$995	$1,148	$1,300	$1,466	$1,590
	Average	$317	$667	$995	$1,300	$1,621	$1,990	$2,295	$2,601	$2,932	$3,181
	High	$633	$1,334	$1,990	$2,601	$3,241	$3,980	$4,591	$5,201	$5,864	$6,362
College Ave./Edgewood Ave.	Low	$207	$441	$650	$854	$1,070	$1,306	$1,519	$1,728	$1,952	$2,116
	Average	$415	$882	$1,300	$1,707	$2,141	$2,612	$3,038	$3,456	$3,905	$4,232
	High	$829	$1,764	$2,601	$3,415	$4,281	$5,224	$6,075	$6,912	$7,809	$8,465

Table 5.2 – Total Expected Annual Revenue for Network Based on Weekday Traffic

Charge	Percent of Vehicles Requesting Priority									
	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Low	$1,396	$3,239	$4,832	$6,430	$8,032	$9,660	$11,254	$12,844	$14,442	$15,712
Average	$3,170	$6,479	$9,663	$12,859	$16,063	$19,319	$22,508	$25,689	$28,885	$31,425
High	$6,339	$12,957	$19,327	$25,719	$32,126	$38,639	$45,016	$51,377	$57,770	$62,850

Table 5.3 – Range of Delay Reductions per Vehicle and Equivalent Benefit per Vehicle

Range of Delay Reduction	Percent of Vehicles Requesting Priority									
	10%		20%		30%		40%		50%	
	Delay Reduction [s]	Benefit/ Vehicle [$]	Delay Reduction [s]	Benefit/ Vehicle [$]	Delay Reduction [s]	Benefit/ Vehicle [$]	Delay Reduction [s]	Benefit/ Vehicle [$]	Delay Reduction [s]	Benefit/ Vehicle [$]
Low	2.5	$0.00889	0.5	$0.00178	0.5	$0.00178	0.5	$0.00178	0.0	$0.00000
Average	3.5	$0.01244	1.5	$0.00533	1.0	$0.00356	1.0	$0.00356	0.5	$0.00178
High	4.5	$0.01600	2.5	$0.00889	1.5	$0.00533	1.5	$0.00533	1.0	$0.00356

Table 5.4 – Expected Annual Benefit from Reduced Network Delay up to 50% CV Penetration Based on Weekday Traffic

Delay Reduction	Percent of Vehicles Requesting Priority				
	10%	20%	30%	40%	50%
Low	43,356	8,671	8,671	8,671	-
Average	60,699	26,014	17,343	17,343	8,671
High	78,042	34,685	26,014	26,014	17,343

Table 5.5 – Sum of Expected Annual Revenue and Expected Annual Benefit from Reduced Delay

Charge/ Delay	Percent of Vehicles Requesting Priority									
	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Low	$44,753	$11,911	$13,503	$15,101	$8,032	$9,660	$11,254	$12,844	$14,442	$15,712
Average	$63,869	$32,493	$27,006	$30,202	$24,734	$19,319	$22,508	$25,689	$28,885	$31,425
High	$84,381	$56,314	$45,341	$51,733	$49,469	$38,639	$45,016	$51,377	$57,770	$62,850

5.2 System Cost

The cost to implement the priority payment system with the ability to retime traffic signals also had to be estimated for this analysis. In Section 2.4 the cost of a TSP system was estimated to range from $5,000 to $30,000 per intersection while a Co-Pilot analysis suggested a cost of about $12,000 per intersection. To be on the conservative side, the lowest cost considered for the system will be the $12,000 per intersection estimated by Co-Pilot and $30,000 per intersection will be the upper limit of the potential cost. These values were then converted to annual costs assuming a 5% interest rate and a 5 and 10 year payback period. The annual system cost per intersection is estimated to range from $2,772 - $6,929 and $1,554 - $3,885 for the 5 and 10 year payback periods respectively. For analysis these costs will be multiplied by 7, the number of signalized intersections in the study network.

5.3 Results of Benefit-Cost Analysis

Tables 5.6 – 5.9 show the results of the benefit-cost analysis for each case considered based only on revenue from CV. Based on these results it is possible that the project cost could be recovered solely through revenue generated by allowing CVs to request priority in the major direction of flow.

The highest CV penetration level at which there was a statistically significant advantage for connected vehicles over non-connected vehicles was 40%. The lowest CV penetration level at which a benefit-cost ratio greater than 1.00 is 20%. At 40% CV penetration levels three scenarios have a benefit-cost ratio greater than 1.00: i) a low system cost with 5 year payback period and high price to request priority, ii) a low system cost with a 10 year payback and high price to request priority, and iii) a low system cost with a 10 year payback and an average price to request priority.

Tables 5.10 – 5.13 show the results of the benefit-cost analysis for each case when revenue and the benefit of reduced delay are both considered. For this case 5 of the 12 scenarios have a benefit-cost ratio greater than 1.00 for all CV penetration levels. The large reduction in delay at 10% CV penetration levels results is a benefit-cost ratio greater than 1.00 for 11 of the 12 scenarios. This is a very promising result because it shows that even if the project cost cannot be made up for with revenue from connected vehicle priority requests at penetration levels less than 20%, the added benefit of enhanced network performance makes up for the revenue shortfalls from the priority requests of connected vehicles.

Table 5.6 – B/C Results: $12,000 Installation Cost, 5 Year Payback, Revenue Only

Charge	Percent of Vehicles Requesting Priority									
	10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Low	0.07	0.17	0.25	0.33	0.41	0.50	0.58	0.66	0.74	0.81
Average	0.16	0.33	0.50	0.66	0.83	1.00	1.16	1.32	1.49	1.62
High	0.33	0.67	1.00	1.33	1.66	1.99	2.32	2.65	2.98	3.24

Table 5.7 – B/C Results: $30,000 Installation Cost, 5 Year Payback, Revenue Only

Charge	Percent of Vehicles Requesting Priority									
	10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Low	0.03	0.07	0.10	0.13	0.17	0.20	0.23	0.26	0.30	0.32
Average	0.07	0.13	0.20	0.27	0.33	0.40	0.46	0.53	0.60	0.65
High	0.13	0.27	0.40	0.53	0.66	0.80	0.93	1.06	1.19	1.30

Table 5.8 – B/C Results: $12,000 Installation Cost, 10 Year Payback, Revenue Only

Charge	Percent of Vehicles Requesting Priority									
	10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Low	0.13	0.30	0.44	0.59	0.74	0.89	1.03	1.18	1.33	1.44
Average	0.29	0.60	0.89	1.18	1.48	1.78	2.07	2.36	2.66	2.89
High	0.58	1.19	1.78	2.36	2.95	3.55	4.14	4.72	5.31	5.78

Table 5.9 – B/C Results: $30,000 Installation Cost, 10 Year Payback, Revenue Only

Charge	Percent of Vehicles Requesting Priority									
	10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Low	0.05	0.12	0.18	0.24	0.30	0.36	0.41	0.47	0.53	0.58
Average	0.12	0.24	0.36	0.47	0.59	0.71	0.83	0.94	1.06	1.16
High	0.23	0.48	0.71	0.95	1.18	1.42	1.66	1.89	2.12	2.31

Table 5.10 – B/C Results: $12,000 Installation Cost, 5 Year Payback, Revenue & Benefit from Delay Reduction

Charge/Delay Reduction	**Percent of Vehicles Requesting Priority**									
	10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Low	2.31	0.61	0.70	0.78	0.41	0.50	0.58	0.66	0.74	0.81
Average	3.29	1.67	1.39	1.56	1.27	1.00	1.16	1.32	1.49	1.62
High	4.35	2.46	2.34	2.67	2.55	1.99	2.32	2.65	2.98	3.24

Table 5.11 – B/C Results: $30,000 Installation Cost, 5 Year Payback, Revenue & Benefit from Delay Reduction

Charge/Delay Reduction	**Percent of Vehicles Requesting Priority**									
	10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Low	0.92	0.25	0.28	0.31	0.17	0.20	0.23	0.26	0.30	0.32
Average	1.32	0.67	0.56	0.62	0.51	0.40	0.46	0.53	0.60	0.65
High	1.74	0.98	0.93	1.07	1.02	0.80	0.93	1.06	1.19	1.30

Table 5.12 – B/C Results: $12,000 Installation Cost, 10 Year Payback, Revenue & Benefit from Delay Reduction

Charge/Delay Reduction	**Percent of Vehicles Requesting Priority**									
	10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Low	4.11	1.09	1.24	1.39	0.74	0.89	1.03	1.18	1.33	1.44
Average	5.87	2.99	2.48	2.78	2.27	1.78	2.07	2.36	2.66	2.89
High	7.76	4.38	4.17	4.76	4.55	3.55	4.14	4.72	5.31	5.78

Table 5.13 – B/C Results: $30,000 Installation Cost, 10 Year Payback, Revenue & Benefit from Delay Reduction

Charge/Delay Reduction	**Percent of Vehicles Requesting Priority**									
	10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Low	1.65	0.44	0.50	0.56	0.30	0.36	0.41	0.47	0.53	0.58
Average	2.35	1.19	0.99	1.11	0.91	0.71	0.83	0.94	1.06	1.16
High	3.10	1.75	1.67	1.90	1.82	1.42	1.66	1.89	2.12	2.31

CHAPTER SIX

CONCLUSIONS AND RECCOMENDATIONS

6.1 Conclusions

This research evaluated traffic operation efficiency of urban corridors when connected vehicles were allowed to pay a small fee to request priority at a signalized intersection, similar to a transit signal priority system, in a mixed traffic environment that included connected and non-connected vehicles. An existing network containing 8 signalized and 11 signalized intersections was modeled in VISSIM. Initially, the scenarios not containing connected vehicles, the existing conditions, optimized signal timings, and coordinated signal plans, were compared to one another. The lowest delay of all scenarios not containing connected vehicles was the scenario in which each intersection's cycle length and split was optimized individually. Conversely, the coordinated scenario produced the highest delay in the study, probably due to the fact that the Synchro analysis placed too much focus on US 93 and not enough on the College Avenue corridor. The alternate scenarios containing connected vehicles were compared to the optimized signal timing condition to eliminate any bias due to inaccurately timed signals.

Next, several alternate scenarios containing different priority request direction permissions and different connected vehicle penetration levels were simulated. Connected vehicle penetration levels ranging from 0% (no connected vehicles) to 100% were evaluated and delay difference between connected and non-connected vehicles was analyzed and the delay for all vehicle types was compared to the results from the optimized signal timing scenario to determine the effectiveness of the concept presented in this thesis.

Analysis of network delay for connected versus non-connected vehicles revealed that, on average, connected vehicles experience less delay than non-connected vehicles up to 20% CV penetration levels when priority was allowed to be requested from all directions and in both directions on the major corridors at a signalized intersection. Additionally, CVs experienced less delay than non-connected vehicles at up to 40% CV penetration levels when priority was only allowed to be requested in the direction of highest flow on the major corridors.

The delay for all vehicle types was also analyzed which revealed that the scenario which allowed connected vehicles to request priority in only one direction was the only scenario where the average delay per vehicle was consistently less than the average delay per vehicle for the optimized signal timing scenario. The one-way scenario had significantly less delay up to 50% CV penetration levels. Another observation is that the average delay per vehicle increased as the CV penetration levels increased. This is probably due to the fact that vehicles were selfishly competing for green time instead of sharing information and trying to optimize the signal timing for all vehicles. Thus, as more vehicles tried to request green time for themselves, the average delay per vehicle increased. Instead of determining a critical value where the system with connected vehicles performed better than the comparison scenario, this research identified a critical value of 50% CV penetration for one-way priority requests where the network actually performs worse than the comparison scenario.

A benefit-cost analysis was performed for the one-way priority request scenario because it was the only scenario that outperformed the base scenario. It was found that when the benefits only included revenue generated by connected vehicles requesting priority, the lowest CV penetration levels with a benefit-cost ratio higher than 1.00 was 20%. This is a good finding because it shows that once the CV penetration levels are high enough, the system can pay for itself and generate some profit.

An additional benefit-cost analysis was performed that included the revenue generated by CV priority requests as well as the reduction in overall network delay as benefits to society. For this case the large reduction of average delay per vehicle at the lower levels of CV penetration helped to greatly boost the benefit-cost ratios. 11 of the 12 scenarios had a benefit-cost ratio greater than 1.00 at a 10% CV penetration level while 5 of the 12 scenarios maintained a benefit-cost ratio of at least 1.00 for all levels of CV penetration. This result helps to prove the viability of system implementation because even if the system cannot pay for itself immediately in terms of revenue the system is still generating enough benefits in terms of reduced delay to cover the gap in revenue.

The pay for priority system proposed in this paper offers travelers the choice to pay a very small fee to request priority at a signalized intersection. This fee is not required and all travelers may use the intersection like normal regardless of ability or willingness to pay. Theoretically, this type of system would benefit the wealthy travelers who have more money to spend on services and who may place a higher value on their time than the average person. This type system behavior is observed at CV penetration levels up to 20% for all-way and two-way priority permission scenarios and up to 40% for the one-way priority permission scenario. Once CV penetration levels increase above these thresholds all vehicle types were found to experience similar quality of service. The fact that the intersection remains under signalized control means that when a payer receives a green indication, all other non-payers on that approach are also allowed to enter the intersection. While the all-way and two-way scenarios display advantages for connected vehicles when compared to non-connected vehicles, the average delay per vehicles is actually greater than the base conditions for these scenarios therefore it is unlikely that they will ever be implemented. However, the one-way scenario performs better than the base scenario up to 50% CV penetration levels. Because of this, non-payers can experience faster travel times on the network as long as the percentage of CV paying to request priority stays below 50%. This seems like a logical assumption because CV payers only experience an advantage over non-payers up to 40% penetration levels of CV paying for priority. Therefore, as long as the level of CV paying to request priority stays at or below 50%, this is a fair system for everyone on the traffic network including non-connected vehicles and connected vehicles.

6.2 Recommendations for Future Research

- A pay for priority system that uses connected vehicle technology to allow travelers to request priority in the direction of highest flow at a signalized intersections is a viable project for the future with connected vehicles on the arterials.

- Future attempts to model vehicles requesting signal priority in VISSIM may consider creating a custom code to specifically deal with issues of many conflicting signal priority requests. Researchers could also explore alternate VISSIM add-ons that will do a better job simulating connected vehicle communication in the model, such as integrating VISSIM with a network communication simulator Version 3 (ns-3).
- The concept of allowing travelers to pay for priority at an intersection has merit from a financial standpoint if enough drivers are willing to pay. This concept should be explored in further detail through additional simulation studies as well as public opinion studies. When presenting the idea to the public it is important to keep the policy as simple as possible and to compare it to other transportation strategies that people are familiar with, such as transit signal priority.
- Future studies should take revealed public opinion on the policy into account and make necessary changes to make the connected vehicle signal priority concept presented in this thesis as appealing as possible to the public.

APPENDICES

Appendix A

Vehicle Volume and Turning Movement Data from Field Collection

File Name:	93 @ Perimeter
Start Date:	3/12/2015
Start Time:	4:00:00 PM
Site Code:	00312151
Comment 1:	Intersection #1
Comment 2:	Data collected by: Melissa Gende
Comment 3:	
Comment 4:	

	From North				From East				From South				From West			
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds
4:00 PM	0	0	0	0	0	24	1	1	10	0	25	0	27	13	0	0
4:05 PM	0	0	0	0	0	24	6	0	14	0	34	0	25	22	0	1
4:10 PM	0	0	0	0	0	13	3	0	13	0	38	0	24	15	1	0
4:15 PM	0	0	0	0	0	18	8	0	14	0	35	0	10	17	1	1
4:20 PM	0	0	0	3	0	14	2	3	10	0	23	0	18	24	0	6
4:25 PM	0	0	0	0	0	26	7	0	15	0	15	0	21	17	0	0
4:30 PM	1	0	0	0	0	20	3	0	15	0	40	0	24	23	0	0
4:35 PM	0	0	0	0	0	33	6	0	19	0	42	1	22	22	0	0
4:40 PM	0	0	1	0	0	26	8	0	18	0	38	0	18	26	0	1
4:45 PM	0	0	0	1	0	18	5	0	16	0	43	0	24	8	0	0
4:50 PM	0	0	0	0	0	23	9	0	25	0	26	1	31	24	0	0
4:55 PM	0	0	0	0	0	17	4	0	18	0	31	0	12	12	0	1
5:00 PM	0	0	0	0	0	18	6	0	20	0	25	0	34	15	0	12
5:05 PM	0	0	0	0	0	34	7	0	18	0	40	0	18	14	0	23
5:10 PM	0	0	0	0	0	31	14	0	14	0	35	0	22	25	0	0
5:15 PM	1	0	0	0	0	31	10	0	23	0	27	0	29	18	0	0
5:20 PM	0	0	0	0	0	19	7	0	17	0	48	0	30	18	0	0
5:25 PM	0	0	0	0	0	26	8	0	17	0	40	0	36	27	0	0
5:30 PM	0	0	0	0	0	20	4	0	13	1	43	0	36	18	0	2
5:35 PM	0	0	1	0	0	26	7	0	13	0	29	0	23	15	0	1
5:40 PM	0	0	1	0	0	16	3	0	17	2	25	0	20	19	0	0
5:45 PM	0	0	0	0	0	15	7	0	9	0	32	0	32	20	0	1
5:50 PM	0	0	0	0	0	13	8	1	11	0	19	0	18	14	0	0
5:55 PM	0	0	0	0	0	20	1	0	12	0	27	0	12	17	0	0
Total	2	0	3	4	0	525	144	5	371	3	780	2	566	443	2	49

15 Minute Volumes

15	0	0	0	0	0	61	10	1	37	0	97	0	76	50	1	1
30	0	0	0	3	0	58	17	3	39	0	73	0	49	58	1	7
45	1	0	1	0	0	79	17	0	52	0	120	1	64	71	0	1
60	0	0	0	1	0	58	18	0	59	0	100	1	67	44	0	1
75	0	0	0	0	0	83	27	0	52	0	100	0	74	54	0	35
90	1	0	0	0	0	76	25	0	57	0	115	0	95	63	0	0
105	0	0	2	0	0	62	14	0	43	3	97	0	79	52	0	3
120	0	0	0	0	0	48	16	1	32	0	78	0	62	51	0	1

File Name:	93 @ Oak
Start Date:	3/24/2015
Start Time:	4:00:00 PM
Site Code:	324152
Comment 1:	Intersection #2
Comment 2:	Data Collected by: Melissa Gende
Comment 3:	
Comment 4:	

	From North				From East				From South				From West			
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds
4:00 PM	2	0	2	0	3	0	0	0	0	0	0	1	0	0	2	0
4:05 PM	2	0	4	0	1	0	0	0	0	0	0	0	0	0	5	0
4:10 PM	5	0	3	2	2	0	0	0	0	0	0	0	0	0	4	0
4:15 PM	3	0	2	0	0	0	0	0	0	0	0	1	0	0	7	0
4:20 PM	3	0	5	0	3	0	0	0	0	0	0	4	0	0	4	0
4:25 PM	3	0	2	0	4	0	0	0	0	0	0	0	0	0	5	0
4:30 PM	7	0	0	1	0	0	0	0	0	0	0	6	0	0	8	0
4:35 PM	7	0	3	1	3	0	0	0	0	0	0	0	0	0	7	0
4:40 PM	6	0	2	0	4	0	0	0	0	0	0	2	0	0	1	0
4:45 PM	2	0	2	0	1	0	0	0	0	0	0	0	0	0	1	0
4:50 PM	7	0	4	0	10	0	0	0	0	0	0	0	0	0	8	0
4:55 PM	3	0	3	1	4	0	0	0	0	0	0	2	0	0	11	0
5:00 PM	9	0	5	0	4	0	0	0	0	0	0	0	0	0	4	0
5:05 PM	4	0	2	0	4	0	0	0	0	0	0	1	0	0	9	0
5:10 PM	5	0	3	0	3	0	0	0	0	0	0	1	0	0	6	0
5:15 PM	6	0	2	0	4	0	0	0	0	0	0	0	0	0	3	0
5:20 PM	5	0	3	0	4	0	0	0	0	0	0	0	0	0	5	0
5:25 PM	6	0	4	1	3	0	0	0	0	0	0	1	0	0	3	0
5:30 PM	5	0	4	2	4	0	0	0	0	0	0	0	0	0	1	0
5:35 PM	4	0	4	0	2	0	0	0	0	0	0	0	0	0	5	0
5:40 PM	5	0	3	0	1	0	0	0	0	0	0	0	0	0	10	0
5:45 PM	2	0	3	0	0	0	0	0	0	0	0	0	0	0	4	0
5:50 PM	2	0	2	0	1	0	0	0	0	0	0	1	0	0	8	0
5:55 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	101	0	65	8	64	0	0	0	0	0	0	19	0	0	113	0

15 Minute Volumes

15	9	0	9	2	6	0	0	0	0	0	0	1	0	0	11	0
30	9	0	9	0	7	0	0	0	0	0	0	5	0	0	16	0
45	20	0	5	2	7	0	0	0	0	0	0	8	0	0	16	0
60	12	0	9	1	15	0	0	0	0	0	0	2	0	0	20	0
75	18	0	10	0	11	0	0	0	0	0	0	2	0	0	19	0
90	17	0	9	1	11	0	0	0	0	0	0	1	0	0	11	0
105	14	0	11	2	7	0	0	0	0	0	0	0	0	0	16	0
120	4	0	5	0	1	0	0	0	0	0	0	1	0	0	12	0

File Name:	93 @ Centennial
Start Date:	3/24/2015
Start Time:	4:00:00 PM
Site Code:	00324153
Comment 1:	Intersection #3
Comment 2:	JMAR #3
Comment 3:	Data Collected by: Melissa Gende
Comment 4:	

	From North				From East				From South				From West			
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds
4:00 PM	0	0	1	0	0	29	0	0	6	0	1	1	0	31	0	6
4:05 PM	0	0	0	0	0	33	2	2	2	0	0	0	0	29	0	6
4:10 PM	0	0	0	1	1	21	0	2	3	0	0	0	0	16	0	5
4:15 PM	0	0	0	0	0	16	0	4	9	0	3	1	0	37	0	4
4:20 PM	0	0	0	4	0	18	1	0	8	0	1	0	1	29	0	10
4:25 PM	0	0	0	0	0	27	0	0	1	0	0	0	0	25	0	3
4:30 PM	0	0	1	2	0	25	0	1	6	0	2	1	0	31	0	5
4:35 PM	0	0	1	0	0	45	0	1	7	0	1	0	0	42	0	4
4:40 PM	0	0	0	1	0	40	0	2	5	0	3	0	0	50	0	6
4:45 PM	1	0	0	0	1	31	0	0	6	0	0	0	0	38	0	6
4:50 PM	0	0	0	1	0	37	2	1	4	0	1	0	0	40	0	5
4:55 PM	0	0	0	3	1	34	0	0	11	0	2	0	0	38	0	1
5:00 PM	0	0	0	0	0	30	3	2	3	0	2	0	0	58	1	7
5:05 PM	0	0	2	0	1	46	1	0	10	0	1	0	0	32	0	10
5:10 PM	1	1	2	0	0	46	1	0	5	0	0	0	0	49	0	5
5:15 PM	0	0	0	1	1	44	0	1	4	0	2	0	0	27	0	2
5:20 PM	0	0	0	0	0	53	0	0	2	0	0	0	0	45	0	4
5:25 PM	0	0	0	0	0	32	0	1	5	0	1	0	0	40	0	8
5:30 PM	0	0	0	0	0	35	1	2	4	0	2	0	0	38	0	5
5:35 PM	0	0	0	1	1	34	1	0	1	0	1	0	0	56	0	2
5:40 PM	1	0	0	0	0	28	0	3	1	0	1	0	0	25	1	12
5:45 PM	0	0	1	0	0	19	0	0	4	0	1	0	0	25	1	3
5:50 PM	0	0	0	3	0	25	0	0	2	0	2	0	0	36	0	6
5:55 PM	0	0	0	0	0	22	0	3	1	0	0	1	0	27	0	9
Total	3	1	8	17	6	770	12	25	110	0	27	4	1	864	3	134

15 Minute Volumes

15	0	0	1	1	1	83	2	4	11	0	1	1	0	76	0	17
30	0	0	0	4	0	61	1	4	18	0	4	1	1	91	0	17
45	0	0	2	3	0	110	0	4	18	0	6	1	0	123	0	15
60	1	0	0	4	2	102	2	1	21	0	3	0	0	116	0	12
75	1	1	4	0	1	122	5	2	18	0	3	0	0	139	1	22
90	0	0	0	1	1	129	0	2	11	0	3	0	0	112	0	14
105	1	0	0	1	1	97	2	5	6	0	4	0	0	119	1	19
120	0	0	1	3	0	66	0	3	7	0	3	1	0	88	1	18

File Name:	93 @ Williamson/Pine
Start Date:	4/16/2015
Start Time:	4:00:00 PM
Site Code:	00416155
Comment 1:	Intersection #5
Comment 2:	JMAR #3
Comment 3:	Data Collected by: Melissa Gende
Comment 4:	

	From Pine				From East				From Williamson				From West			
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds
06:00 PM	2	1	1	0	2	12	4	0	26	1	15	0	4	19	0	3
06:05 PM	0	0	0	0	2	13	14	0	32	0	22	2	5	22	0	0
06:10 PM	2	0	2	0	1	15	15	0	22	0	14	0	5	21	0	1
06:15 PM	2	2	4	0	1	14	20	0	25	0	7	2	8	25	0	1
06:20 PM	1	4	7	0	0	16	17	0	31	0	9	1	6	22	0	1
06:25 PM	0	1	1	0	4	19	16	0	27	1	12	1	8	22	0	0
06:30 PM	2	1	2	1	3	20	13	0	29	1	13	0	6	32	0	2
06:35 PM	4	2	2	0	1	22	9	0	32	7	25	1	9	23	0	2
06:40 PM	4	5	7	1	0	14	11	2	36	4	15	0	3	33	0	2
06:45 PM	1	4	5	1	0	30	21	0	39	0	10	2	7	15	0	2
06:50 PM	2	2	2	0	1	17	16	0	43	3	12	2	4	32	0	4
06:55 PM	0	2	4	0	1	27	18	0	32	2	8	0	4	36	0	1
07:00 PM	4	3	5	1	2	22	13	0	45	3	16	1	7	42	0	0
07:05 PM	2	5	5	0	1	23	12	0	39	4	11	0	4	40	0	0
07:10 PM	4	3	5	0	4	18	12	1	34	3	14	0	3	34	0	0
07:15 PM	3	3	6	0	2	28	25	0	19	3	9	4	5	40	0	0
07:20 PM	7	3	6	1	2	26	14	0	36	0	5	0	2	45	0	2
07:25 PM	2	0	3	0	2	23	13	1	35	0	7	0	4	27	0	0
07:30 PM	1	2	3	1	0	18	12	1	29	1	5	1	7	34	0	2
07:35 PM	1	2	5	0	1	15	12	0	33	0	11	0	7	24	0	1
07:40 PM	1	2	3	0	0	15	13	1	23	2	8	1	3	26	0	0
07:45 PM	4	3	4	2	0	22	18	0	22	1	7	1	1	35	0	4
07:50 PM	4	2	4	0	1	15	10	0	23	0	7	1	7	19	0	1
07:55 PM	0	5	7	0	0	19	18	0	27	6	8	2	9	16	0	5
Total	53	57	93	8	31	463	346	6	739	42	270	22	128	684	0	34

15 Minute Volumes

15	4	1	3	0	5	40	33	0	80	1	51	2	14	62	0	4
30	3	7	12	0	5	49	53	0	83	1	28	4	22	69	0	2
45	10	8	11	2	4	56	33	2	97	12	53	1	18	88	0	6
60	3	8	11	1	2	74	55	0	114	5	30	4	15	83	0	7
75	10	11	15	1	7	63	37	1	118	10	41	1	14	116	0	0
90	12	6	15	1	6	77	52	1	90	3	21	4	11	112	0	2
105	3	6	11	1	1	48	37	2	85	3	24	2	17	84	0	3
120	8	10	15	2	1	56	46	0	72	7	22	4	17	70	0	10

File Name:	93 @ Mountain View
Start Date:	4/9/2015
Start Time:	4:00:00 PM
Site Code:	00416155
Comment 1:	Intersection #6
Comment 2:	JMAR #3
Comment 3:	Data Collected by: Melissa Gende
Comment 4:	

	From North				From East				From South				From West			
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds
4:00 PM	0	0	1	0	0	22	0	0	0	0	0	0	0	51	1	0
4:05 PM	1	0	0	0	0	33	0	0	0	0	0	0	0	53	0	0
4:10 PM	1	0	0	0	1	34	0	0	0	0	0	0	0	49	1	0
4:15 PM	2	0	0	0	0	39	0	0	0	0	0	0	0	63	1	0
4:20 PM	3	0	1	0	1	36	0	0	0	0	0	0	0	55	0	0
4:25 PM	1	0	1	0	1	27	0	0	0	0	0	0	0	49	0	0
4:30 PM	0	0	0	0	0	31	0	0	0	0	0	0	0	60	1	0
4:35 PM	1	0	1	0	0	30	0	0	0	0	0	0	0	64	1	0
4:40 PM	0	0	0	0	0	22	0	0	0	0	0	0	0	62	0	0
4:45 PM	0	0	1	0	2	39	0	0	0	0	0	0	0	65	0	0
4:50 PM	1	0	0	0	0	37	0	0	0	0	0	0	0	72	2	0
4:55 PM	2	0	1	0	0	42	0	0	0	0	0	0	0	67	1	0
5:00 PM	1	0	1	0	0	26	0	0	0	0	0	0	0	79	0	0
5:05 PM	2	0	0	0	1	29	0	0	0	0	0	0	0	81	0	0
5:10 PM	1	0	1	0	0	28	0	0	0	0	0	0	0	62	1	0
5:15 PM	0	0	0	0	0	43	0	0	0	0	0	0	0	73	1	0
5:20 PM	1	0	0	0	1	41	0	0	0	0	0	0	0	51	0	0
5:25 PM	3	0	1	0	0	36	0	0	0	0	0	0	0	58	2	0
5:30 PM	1	0	0	0	1	36	0	0	0	0	0	0	0	60	1	0
5:35 PM	0	0	0	0	0	29	0	0	0	0	0	0	0	68	1	0
5:40 PM	1	0	0	0	0	23	0	0	0	0	0	0	0	54	0	0
5:45 PM	1	0	1	0	0	26	0	0	0	0	0	0	0	58	1	0
5:50 PM	1	0	0	0	0	21	0	0	0	0	0	0	0	44	1	0
5:55 PM	0	0	0	0	0	28	0	0	0	0	0	0	0	48	0	0
Total	24	0	10	0	8	758	0	0	0	0	0	0	0	1446	16	0

15 Minute Volumes

15	2	0	1	0	1	89	0	0	0	0	0	0	0	153	2	0
30	6	0	2	0	2	102	0	0	0	0	0	0	0	167	1	0
45	1	0	1	0	0	83	0	0	0	0	0	0	0	186	2	0
60	3	0	2	0	2	118	0	0	0	0	0	0	0	204	3	0
75	4	0	2	0	1	83	0	0	0	0	0	0	0	222	1	0
90	4	0	1	0	1	120	0	0	0	0	0	0	0	182	3	0
105	2	0	0	0	1	88	0	0	0	0	0	0	0	182	2	0
120	2	0	1	0	0	75	0	0	0	0	0	0	0	150	2	0

File Name:	93 @ College Ave
Start Date:	3/31/2015
Start Time:	4:00:00 PM
Site Code:	00331157
Comment 1:	Intersection #7
Comment 2:	JMAR #3
Comment 3:	Data Collected by: Melissa Gende
Comment 4:	

	From North				From East				From South				From West			
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds
4:00 PM	9	0	14	6	35	17	0	2	0	0	0	1	0	32	13	0
4:05 PM	10	0	23	25	21	19	0	3	0	0	0	3	0	37	21	0
4:10 PM	10	0	14	17	29	17	0	9	0	0	0	4	0	28	24	0
4:15 PM	10	0	19	25	29	27	0	5	0	0	0	2	0	40	18	0
4:20 PM	8	0	20	20	21	23	0	0	0	0	0	7	0	34	18	0
4:25 PM	14	0	29	17	22	15	0	0	0	0	0	9	0	22	11	0
4:30 PM	9	0	20	29	19	31	0	9	0	0	0	7	0	42	9	0
4:35 PM	8	0	30	26	37	36	0	2	0	0	0	4	0	47	19	0
4:40 PM	6	0	24	16	23	32	0	5	0	0	0	9	0	60	23	0
4:45 PM	12	0	36	18	27	24	0	2	0	0	0	14	0	42	18	0
4:50 PM	6	0	21	31	31	26	0	10	0	0	0	9	0	58	21	0
4:55 PM	11	0	38	29	31	38	0	1	0	0	0	10	0	50	22	0
5:00 PM	5	0	21	21	31	17	0	6	0	0	0	7	0	61	28	0
5:05 PM	6	0	24	20	41	43	0	7	0	0	0	5	0	72	21	0
5:10 PM	15	0	30	27	22	33	0	2	0	0	0	11	0	37	19	0
5:15 PM	9	0	23	17	32	39	0	2	0	0	0	7	0	59	26	0
5:20 PM	11	0	34	17	28	27	0	0	0	0	0	7	0	28	17	0
5:25 PM	7	0	20	13	32	26	0	2	0	0	0	2	0	51	25	0
5:30 PM	11	0	24	29	33	25	0	7	0	0	0	9	0	40	16	0
5:35 PM	13	0	15	18	27	31	0	2	0	0	0	16	0	51	26	0
5:40 PM	17	0	25	19	31	33	0	2	0	0	0	15	0	40	20	0
5:45 PM	10	0	14	13	28	24	0	5	0	0	0	7	0	43	26	0
5:50 PM	13	0	34	28	31	34	0	5	0	0	0	8	0	32	19	0
5:55 PM	9	0	16	14	32	26	0	9	0	0	0	6	0	53	19	0
Total	239	0	568	495	693	663	0	97	0	0	0	179	0	1059	479	0

15 Minute Volumes

15	29	0	51	48	85	53	0	14	0	0	0	8	0	97	58	0
30	32	0	68	62	72	65	0	5	0	0	0	18	0	96	47	0
45	23	0	74	71	79	99	0	16	0	0	0	20	0	149	51	0
60	29	0	95	78	89	88	0	13	0	0	0	33	0	150	61	0
75	26	0	75	68	94	93	0	15	0	0	0	23	0	170	68	0
90	27	0	77	47	92	92	0	4	0	0	0	16	0	138	68	0
105	41	0	64	66	91	89	0	11	0	0	0	40	0	131	62	0
120	32	0	64	55	91	84	0	19	0	0	0	21	0	128	64	0

File Name:	93 @ Nu Kappa & Sherman
Start Date:	4/14/2015
Start Time:	4:00:00 PM
Site Code:	00414159
Comment 1:	Intersection #8/9
Comment 2:	Data Collected by: Kweku Brown
Comment 3:	
Comment 4:	

	From North				From East				From South				From West			
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds
4:00 PM	10	0	11	0	3	0	0	8	0	0	0	0	0	0	7	0
4:05 PM	4	0	4	0	11	0	0	6	0	0	0	0	0	0	3	0
4:10 PM	6	0	5	0	4	0	0	3	0	0	0	0	0	0	6	0
4:15 PM	4	0	4	0	2	0	0	6	0	0	0	0	0	0	1	0
4:20 PM	2	0	8	1	4	0	0	9	0	0	0	0	0	0	6	0
4:25 PM	2	0	11	0	4	0	0	6	0	0	0	0	0	0	1	0
4:30 PM	8	0	10	0	8	0	0	6	0	0	0	0	0	0	2	0
4:35 PM	9	0	15	0	6	0	0	13	0	0	0	0	0	0	4	0
4:40 PM	7	0	10	1	6	0	0	13	0	0	0	0	0	0	4	0
4:45 PM	9	0	11	0	5	0	0	16	0	0	0	0	0	0	6	0
4:50 PM	7	0	12	1	12	0	0	22	0	0	0	0	0	0	3	0
4:55 PM	3	0	9	0	11	0	0	26	0	0	0	0	0	0	5	0
5:00 PM	9	0	3	0	2	0	0	8	0	0	0	0	0	0	4	0
5:05 PM	3	0	5	0	7	0	0	8	0	0	0	0	0	0	4	0
5:10 PM	8	0	5	0	5	0	0	15	0	0	0	0	0	0	4	0
5:15 PM	3	0	5	0	7	0	0	5	0	0	0	0	0	0	11	0
5:20 PM	4	0	8	0	8	0	0	5	0	0	0	0	0	0	6	0
5:25 PM	3	0	5	1	14	0	0	12	0	0	0	0	0	0	7	0
5:30 PM	6	0	8	1	6	0	0	8	0	0	0	0	0	0	4	0
5:35 PM	3	0	8	0	10	0	0	9	0	0	0	0	0	0	3	8
5:40 PM	7	0	11	1	12	0	0	5	0	0	0	0	0	0	3	0
5:45 PM	4	0	7	0	7	0	0	1	0	0	0	0	0	0	3	1
5:50 PM	5	0	9	0	5	0	0	10	0	0	0	0	0	0	7	0
5:55 PM	8	0	3	1	8	0	0	7	0	0	0	0	0	0	6	0
Total	134	0	187	7	167	0	0	227	0	0	0	0	0	0	110	9

15 Minute Volumes

15	20	0	20	0	18	0	0	17	0	0	0	0	0	0	16	0
30	8	0	23	1	10	0	0	21	0	0	0	0	0	0	8	0
45	24	0	35	1	20	0	0	32	0	0	0	0	0	0	10	0
60	19	0	32	1	28	0	0	64	0	0	0	0	0	0	14	0
75	20	0	13	0	14	0	0	31	0	0	0	0	0	0	12	0
90	10	0	18	1	29	0	0	22	0	0	0	0	0	0	24	0
105	16	0	27	2	28	0	0	22	0	0	0	0	0	0	10	8
120	17	0	19	1	20	0	0	18	0	0	0	0	0	0	16	1

File Name:	93 @ Parkway & Calhoun
Start Date:	4/14/2015
Start Time:	4:00:00 PM
Site Code:	04141511
Comment 1:	Intersections # 10/11
Comment 2:	JMAR #3
Comment 3:	Data Collected by: Melissa Gende
Comment 4:	

	From North				From East				From South				From West			
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds
4:00 PM	5	46	0	11	0	0	0	0	0	34	8	9	3	0	5	0
4:05 PM	3	54	0	2	0	0	0	3	0	63	11	1	5	0	3	0
4:10 PM	5	46	0	3	0	0	0	8	0	41	6	3	4	0	2	0
4:15 PM	3	36	0	3	0	0	0	2	0	40	8	4	3	0	3	0
4:20 PM	7	36	0	2	0	0	0	6	0	41	14	20	3	0	3	0
4:25 PM	13	61	0	1	0	0	0	10	0	57	12	13	2	0	5	0
4:30 PM	9	52	0	4	0	0	0	10	0	53	16	5	5	0	10	0
4:35 PM	15	62	0	2	0	0	0	18	0	52	10	7	20	0	19	0
4:40 PM	24	62	0	2	0	0	0	21	0	59	4	12	4	0	4	0
4:45 PM	17	59	0	6	0	0	0	18	0	59	9	25	3	0	7	0
4:50 PM	18	62	0	12	0	0	0	36	0	55	13	46	8	0	11	0
4:55 PM	20	62	0	7	0	0	0	18	0	49	13	15	9	0	8	0
5:00 PM	9	56	0	2	0	0	0	8	0	36	12	6	10	0	11	1
5:05 PM	13	80	0	5	0	0	0	7	0	67	11	4	6	0	5	0
5:10 PM	5	66	0	4	0	0	0	10	0	71	17	10	7	0	6	0
5:15 PM	6	54	0	5	0	0	0	10	0	52	16	12	6	0	5	0
5:20 PM	9	71	0	4	0	0	0	6	0	57	7	23	3	0	6	0
5:25 PM	7	55	0	8	0	0	0	5	0	53	11	14	6	0	8	0
5:30 PM	8	59	0	3	0	0	0	8	0	64	13	2	5	0	5	0
5:35 PM	10	43	0	6	0	0	0	11	0	55	12	6	3	0	4	0
5:40 PM	7	36	0	7	0	0	0	7	0	45	18	7	6	0	8	0
5:45 PM	10	50	0	5	0	0	0	4	0	49	20	7	3	0	7	0
5:50 PM	9	50	0	8	0	0	0	10	0	45	9	17	9	0	4	0
5:55 PM	10	51	0	1	0	0	0	5	0	57	9	1	9	0	6	0
Total	242	1309	0	113	0	0	0	241	0	1254	279	269	142	0	155	1

15 Minute Volumes

15	13	146	0	16	0	0	0	11	0	138	25	13	12	0	10	0
30	23	133	0	6	0	0	0	18	0	138	34	37	8	0	11	0
45	48	176	0	8	0	0	0	49	0	164	30	24	29	0	33	0
60	55	183	0	25	0	0	0	72	0	163	35	86	20	0	26	0
75	27	202	0	11	0	0	0	25	0	174	40	20	23	0	22	1
90	22	180	0	17	0	0	0	21	0	162	34	49	15	0	19	0
105	25	138	0	16	0	0	0	26	0	164	43	15	14	0	17	0
120	29	151	0	14	0	0	0	19	0	151	38	25	21	0	17	0

File Name:	93 @ Cherry
Start Date:	4/16/2015
Start Time:	4:00:00 PM
Site Code:	04161512
Comment 1:	Intersection #12
Comment 2:	JMAR #4
Comment 3:	Data Collected by: Yucheng An
Comment 4:	

	From North				From East				From South				From West			
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds
04:00 PM	0	0	0	0	0	37	6	0	15	0	11	0	9	40	0	0
04:05 PM	0	0	0	0	0	39	16	0	9	0	22	0	5	49	1	0
04:10 PM	0	0	0	0	0	39	9	0	18	0	22	0	12	46	0	0
04:15 PM	0	0	0	0	0	46	11	0	12	0	17	0	12	35	0	0
04:20 PM	1	0	0	0	0	49	13	0	17	0	15	0	6	38	0	0
04:25 PM	0	0	0	0	0	40	15	0	17	0	21	0	11	59	0	0
04:30 PM	0	0	0	0	0	39	11	0	26	0	17	0	14	39	0	0
04:35 PM	0	0	0	0	0	27	14	0	39	0	29	0	16	75	1	0
04:40 PM	2	0	0	0	0	55	19	0	23	0	21	0	17	67	0	0
04:45 PM	0	0	0	0	0	47	17	0	25	0	35	0	18	55	0	0
04:50 PM	0	0	0	0	0	57	19	0	24	0	16	0	14	65	0	0
04:55 PM	0	0	0	0	0	45	23	0	33	0	15	0	15	64	0	0
05:00 PM	0	0	0	0	0	43	8	0	23	0	21	0	25	81	0	0
05:05 PM	0	0	0	0	0	49	13	0	19	0	29	0	12	57	0	0
05:10 PM	0	0	0	0	0	41	16	0	15	0	24	0	14	72	0	0
05:15 PM	0	0	0	0	0	53	17	0	13	0	24	0	8	67	0	0
05:20 PM	0	0	0	0	0	50	19	0	15	0	30	0	11	75	0	0
05:25 PM	0	0	0	0	0	39	14	0	22	0	16	0	13	60	0	0
05:30 PM	0	0	0	0	0	46	14	0	14	0	18	0	12	60	0	0
05:35 PM	0	0	0	0	0	43	13	0	13	0	20	0	20	62	0	0
05:40 PM	0	0	0	0	0	58	16	0	19	0	18	0	9	27	0	0
05:45 PM	0	0	0	0	0	31	25	0	10	0	24	0	12	37	0	0
05:50 PM	0	0	0	0	0	51	18	0	16	0	23	0	11	49	0	0
05:55 PM	0	0	0	0	0	52	14	0	13	0	12	0	10	45	0	0
Total	3	0	0	0	0	1076	360	0	450	0	500	0	306	1324	2	0

15 Minute Volumes

15	0	0	0	0	0	115	31	0	42	0	55	0	26	135	1	0
30	1	0	0	0	0	135	39	0	46	0	53	0	29	132	0	0
45	2	0	0	0	0	121	44	0	88	0	67	0	47	181	1	0
60	0	0	0	0	0	149	59	0	82	0	66	0	47	184	0	0
75	0	0	0	0	0	133	37	0	57	0	74	0	51	210	0	0
90	0	0	0	0	0	142	50	0	50	0	70	0	32	202	0	0
105	0	0	0	0	0	147	43	0	46	0	56	0	41	149	0	0
120	0	0	0	0	0	134	57	0	39	0	59	0	33	131	0	0

File Name: College @ N Clemson & Sloan
Start Date: 4/7/2015
Start Time: 4:00:00 PM
Site Code: 00471513
Comment 1: Intersection 13/14
Comment 2: JMAR #3
Comment 3: Data Collected by: Melissa Gende
Comment 4:

	College Ave SB				Sloan St Veh				College Ave NB				N. Clemson Ave EB			
Start Time	Right	Thru	Left	Peds	Right	Lt. 2 Sl.	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds
4:00 PM	2	23	0	8	1	7	0	8	0	43	0	0	1	0	1	10
4:05 PM	2	33	0	19	0	2	0	3	0	38	1	0	0	0	3	7
4:10 PM	1	29	0	14	0	5	0	10	0	62	0	0	1	0	2	7
4:15 PM	1	27	0	15	1	3	0	6	0	47	4	0	2	0	0	14
4:20 PM	5	31	0	12	1	5	0	3	0	42	0	0	2	0	1	9
4:25 PM	3	25	0	12	0	5	0	6	0	34	3	0	1	0	1	12
4:30 PM	4	33	0	9	2	8	0	5	0	52	1	0	1	0	2	4
4:35 PM	5	34	0	23	0	5	0	9	0	57	2	0	1	0	0	7
4:40 PM	1	37	0	22	1	4	0	10	0	53	0	0	2	0	5	13
4:45 PM	3	33	0	21	3	8	0	12	0	55	3	0	0	0	0	6
4:50 PM	2	38	0	18	0	2	0	9	0	47	1	0	4	0	1	10
4:55 PM	1	27	0	16	0	2	0	4	0	43	0	0	4	0	5	14
5:00 PM	0	36	0	21	2	5	0	5	0	53	0	0	3	0	3	5
5:05 PM	3	38	0	24	1	6	0	8	0	54	1	0	1	0	2	14
5:10 PM	2	32	0	21	4	9	0	3	0	56	1	0	2	0	1	14
5:15 PM	2	27	0	21	2	8	0	8	0	54	2	0	0	0	0	12
5:20 PM	5	40	0	14	1	9	0	18	0	51	1	0	2	0	1	6
5:25 PM	2	42	0	21	2	5	0	8	0	50	0	0	2	0	1	17
5:30 PM	2	34	0	13	1	6	0	4	0	49	0	0	5	0	1	5
5:35 PM	0	24	0	20	0	2	0	10	0	49	2	0	1	0	1	15
5:40 PM	6	36	0	30	0	6	0	10	0	58	1	0	1	0	1	9
5:45 PM	1	25	0	15	2	4	0	3	0	48	3	0	1	0	0	9
5:50 PM	1	36	0	27	2	7	0	4	0	51	4	0	0	0	2	14
5:55 PM	1	36	0	21	1	2	0	13	0	38	3	0	3	0	2	11
Total	55	776	0	437	27	125	0	179	0	1184	33	0	40	0	36	244

15 Minute Volumes

15	5	85	0	41	1	14	0	21	0	143	1	0	2	0	6	24
30	9	83	0	39	2	13	0	15	0	123	7	0	5	0	2	35
45	10	104	0	54	3	17	0	24	0	162	3	0	4	0	7	24
60	6	98	0	55	3	12	0	25	0	145	4	0	8	0	6	30
75	5	106	0	66	7	20	0	16	0	163	2	0	6	0	6	33
90	9	109	0	56	5	22	0	34	0	155	3	0	4	0	2	35
105	8	94	0	63	1	14	0	24	0	156	3	0	7	0	3	29
120	3	97	0	63	5	13	0	20	0	137	10	0	4	0	4	34

File Name:	College @ Earle
Start Date:	4/16/2015
Start Time:	4:00:00 PM
Site Code:	04141515
Comment 1:	Intersection #15
Comment 2:	JMAR #1
Comment 3:	Data Collected by: Nabarjun Vashisth
Comment 4:	

	From North				From East				From South				From West			
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds
4:00 PM	0	24	0	4	0	0	0	9	1	33	0	8	0	0	0	2
4:05 PM	0	39	0	0	0	0	0	0	5	57	0	9	0	0	0	2
4:10 PM	0	29	0	0	0	0	0	1	3	51	0	9	0	0	0	0
4:15 PM	0	27	1	0	0	0	0	14	3	47	0	6	0	0	0	0
4:20 PM	0	25	0	8	0	0	0	5	6	32	0	2	0	0	0	0
4:25 PM	0	28	0	0	0	0	0	9	1	46	0	0	0	0	0	0
4:30 PM	0	29	0	4	0	0	0	6	4	36	0	1	0	0	0	0
4:35 PM	0	26	1	4	0	0	0	10	3	39	0	6	0	0	0	0
4:40 PM	0	37	3	0	0	0	0	5	3	37	0	1	0	0	0	0
4:45 PM	0	25	2	0	0	0	0	10	5	41	0	0	0	0	0	0
4:50 PM	0	35	1	0	0	0	1	10	1	33	0	2	0	0	0	0
4:55 PM	0	30	0	4	0	0	0	27	0	47	0	0	0	0	0	0
5:00 PM	0	24	1	0	0	0	0	17	2	45	0	3	0	0	0	0
5:05 PM	0	43	1	0	0	0	0	12	9	49	0	2	0	0	0	0
5:10 PM	0	50	3	0	0	0	0	11	2	58	0	0	0	0	0	0
5:15 PM	0	30	2	2	0	0	0	3	4	47	0	3	0	0	0	0
5:20 PM	0	44	0	3	0	0	0	6	6	32	0	0	0	0	0	0
5:25 PM	0	24	0	0	0	0	0	9	2	53	0	0	0	0	0	0
5:30 PM	0	38	3	3	0	0	0	13	7	54	0	6	0	0	0	0
5:35 PM	0	34	1	0	0	0	0	6	3	46	0	5	0	0	0	0
5:40 PM	0	43	4	0	0	0	0	8	3	41	0	3	0	0	0	0
5:45 PM	0	31	4	4	0	0	0	9	4	28	0	2	0	0	0	0
5:50 PM	0	36	0	2	0	0	0	5	4	38	0	0	0	0	0	0
5:55 PM	0	38	2	0	0	0	0	10	8	26	0	0	0	0	0	0
Total	0	789	29	38	0	0	1	215	89	1016	0	68	0	0	0	4

15 Minute Volumes

15	0	92	0	4	0	0	0	10	9	141	0	26	0	0	0	4
30	0	80	1	8	0	0	0	28	10	125	0	8	0	0	0	0
45	0	92	4	8	0	0	0	21	10	112	0	8	0	0	0	0
60	0	90	3	4	0	0	1	47	6	121	0	2	0	0	0	0
75	0	117	5	0	0	0	0	40	13	152	0	5	0	0	0	0
90	0	98	2	5	0	0	0	18	12	132	0	3	0	0	0	0
105	0	115	8	3	0	0	0	27	13	141	0	14	0	0	0	0
120	0	105	6	6	0	0	0	24	16	92	0	2	0	0	0	0

File Name:	College @ Keith
Start Date:	4/16/2015
Start Time:	4:00:00 PM
Site Code:	04161516
Comment 1:	Intersection #16
Comment 2:	JMAR #2
Comment 3:	Data Collected by: Logan Reed
Comment 4:	

	From North				From East				From South				From West			
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds
4:00 PM	3	24	4	1	8	0	4	8	5	28	4	9	3	0	4	0
4:05 PM	0	28	5	3	7	0	4	0	1	39	1	3	2	1	4	2
4:10 PM	0	17	4	1	4	1	2	0	0	27	0	8	6	0	3	1
4:15 PM	1	29	8	2	5	1	0	0	3	35	1	4	6	0	3	3
4:20 PM	3	26	5	4	5	0	8	1	4	32	4	3	5	1	4	1
4:25 PM	2	22	2	6	7	0	3	2	5	34	4	1	4	0	2	4
4:30 PM	3	36	1	4	4	0	3	2	3	32	1	5	11	2	6	3
4:35 PM	2	27	5	0	7	1	3	2	1	43	0	7	6	0	6	9
4:40 PM	2	32	5	6	6	0	10	4	0	42	1	6	7	1	7	9
4:45 PM	2	33	5	8	8	0	6	4	2	32	4	6	6	0	3	7
4:50 PM	3	28	5	3	10	1	9	1	4	39	2	6	8	0	5	10
4:55 PM	3	25	2	2	16	0	3	2	5	37	1	6	9	0	7	3
5:00 PM	2	26	4	7	8	0	3	2	2	27	3	8	8	0	7	10
5:05 PM	2	27	3	4	14	1	5	3	2	42	1	7	10	1	7	10
5:10 PM	1	30	6	3	15	0	6	2	5	35	6	8	6	0	7	4
5:15 PM	0	16	4	7	6	3	5	0	6	48	9	6	6	0	6	8
5:20 PM	3	30	6	1	3	0	8	4	3	33	4	1	2	2	3	4
5:25 PM	4	19	4	13	9	1	2	4	0	34	12	3	2	1	5	9
5:30 PM	3	24	3	3	7	0	5	2	2	34	5	3	3	0	4	7
5:35 PM	3	28	7	3	8	0	4	0	4	22	5	5	5	1	3	14
5:40 PM	1	26	5	3	9	2	6	4	4	35	4	7	6	0	8	3
5:45 PM	6	31	2	5	7	0	10	2	2	32	5	2	5	0	1	4
5:50 PM	6	37	4	4	6	1	4	5	2	23	5	7	7	0	3	3
5:55 PM	3	32	6	4	9	0	7	5	4	32	3	3	7	0	10	8
Total	58	653	105	97	188	12	120	59	69	817	85	124	140	10	118	136

15 Minute Volumes

15	3	69	13	5	19	1	10	8	6	94	5	20	11	1	11	3
30	6	77	15	12	17	1	11	3	12	101	9	8	15	1	9	8
45	7	95	11	10	17	1	16	8	4	117	2	18	24	3	19	21
60	8	86	12	13	34	1	18	7	11	108	7	18	23	0	15	20
75	5	83	13	14	37	1	14	7	9	104	10	23	24	1	21	24
90	7	65	14	21	18	4	15	8	9	115	25	10	10	3	14	21
105	7	78	15	9	24	2	15	6	10	91	14	15	14	1	15	24
120	15	100	12	13	22	1	21	12	8	87	13	12	19	0	14	15

File Name:	College @ Edgewood
Start Date:	3/26/2015
Start Time:	4:00:00 PM
Site Code:	03261517
Comment 1:	Intersection #17
Comment 2:	JMAR #3
Comment 3:	Data Collected by: Melissa Gende
Comment 4:	JMAR Board was upside down while counting, fixed lables below.

	From South				From West				From North				From East			
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds
4:00 PM	0	22	1	1	1	0	10	0	9	35	1	2	5	0	0	0
4:05 PM	0	42	0	3	1	0	5	1	7	30	2	1	3	0	1	3
4:10 PM	0	45	1	5	3	0	18	1	10	23	2	0	3	0	2	0
4:15 PM	4	43	0	1	0	0	10	0	6	30	1	1	1	1	0	0
4:20 PM	1	47	0	1	1	0	10	0	4	24	2	2	1	0	0	0
4:25 PM	1	37	1	0	0	2	7	0	9	29	3	0	5	0	0	0
4:30 PM	1	38	0	0	0	0	21	0	5	28	0	2	3	0	4	0
4:35 PM	3	49	1	1	1	0	9	0	13	35	6	2	0	0	0	0
4:40 PM	1	58	1	0	0	2	15	0	10	17	2	2	3	0	0	0
4:45 PM	0	40	0	3	2	0	23	0	8	42	4	1	3	0	2	0
4:50 PM	1	44	0	0	1	0	10	0	14	38	2	3	4	0	0	0
4:55 PM	1	52	0	2	0	0	23	0	9	35	4	2	6	2	1	0
5:00 PM	0	49	0	2	1	1	23	0	7	32	1	1	4	1	0	0
5:05 PM	2	49	0	3	3	0	23	0	9	25	3	0	5	0	0	2
5:10 PM	2	58	0	2	2	0	23	0	6	27	2	4	3	0	1	0
5:15 PM	0	60	1	0	0	0	15	0	11	28	2	3	5	0	0	0
5:20 PM	1	46	0	4	1	0	16	0	10	29	0	5	2	0	0	0
5:25 PM	1	39	0	2	0	1	19	1	13	34	6	1	4	0	0	0
5:30 PM	1	60	0	0	0	0	16	0	9	26	4	2	1	0	3	0
5:35 PM	1	59	0	6	0	0	10	0	8	34	3	3	4	1	0	2
5:40 PM	0	37	0	0	2	1	18	0	7	23	1	6	4	0	1	0
5:45 PM	3	46	0	6	1	0	14	0	8	41	3	14	2	0	1	1
5:50 PM	0	40	0	0	2	0	16	0	6	42	0	14	3	2	2	0
5:55 PM	2	45	0	2	2	1	13	0	10	34	1	7	6	0	1	0
Total	26	1105	6	44	24	8	367	3	208	741	55	78	80	7	19	8

15 Minute Volumes

15	0	109	2	9	5	0	33	2	26	88	5	3	11	0	3	3
30	6	127	1	2	1	2	27	0	19	83	6	3	7	1	0	0
45	5	145	2	1	1	2	45	0	28	80	8	6	6	0	4	0
60	2	136	0	5	3	0	56	0	31	115	10	6	13	2	3	0
75	4	156	0	7	6	1	69	0	22	84	6	5	12	1	1	2
90	2	145	1	6	1	1	50	1	34	91	8	9	11	0	0	0
105	2	156	0	6	2	1	44	0	24	83	8	11	9	1	4	2
120	5	131	0	8	5	1	43	0	24	117	4	35	11	2	4	1

File Name:	133 @ Strode
Start Date:	4/2/2015
Start Time:	4:00:00 PM
Site Code:	00421518
Comment 1:	Intersection #18
Comment 2:	JMAR #3
Comment 3:	Data Collected by: Melissa Gende
Comment 4:	

	From North				From Strode				From South				From Keowee			
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds
4:00 PM	2	34	0	1	6	0	2	0	0	54	1	1	2	0	1	0
4:05 PM	3	23	2	3	2	0	0	0	1	65	0	0	1	0	1	0
4:10 PM	2	36	3	4	2	0	1	0	1	56	1	0	3	0	3	0
4:15 PM	2	36	0	0	2	0	0	0	0	61	1	1	2	0	1	0
4:20 PM	0	34	5	1	0	0	0	0	1	54	0	0	2	0	1	0
4:25 PM	1	48	1	1	2	0	1	0	1	55	2	1	7	0	2	0
4:30 PM	0	30	1	1	3	0	0	0	0	62	2	0	3	0	1	0
4:35 PM	4	41	1	1	1	0	0	0	0	62	0	2	1	0	1	1
4:40 PM	1	41	3	0	3	0	1	0	0	58	0	1	9	0	1	0
4:45 PM	3	42	3	7	2	0	1	0	0	67	1	0	8	0	3	0
4:50 PM	5	43	2	2	4	0	0	0	1	52	4	2	2	0	5	0
4:55 PM	2	49	3	1	2	0	2	0	1	78	1	1	3	0	1	0
5:00 PM	1	51	2	0	3	1	1	0	2	78	1	1	1	0	3	0
5:05 PM	3	40	1	0	4	0	0	0	0	83	1	0	6	0	1	0
5:10 PM	1	41	3	0	6	0	0	0	2	79	0	0	1	0	2	0
5:15 PM	2	47	0	1	3	0	0	0	2	73	0	4	3	0	6	0
5:20 PM	2	36	3	2	4	0	2	1	1	64	1	0	1	0	1	0
5:25 PM	1	41	2	6	2	0	0	0	0	68	1	0	8	0	2	0
5:30 PM	2	36	2	0	1	0	2	0	1	56	3	0	8	0	2	0
5:35 PM	2	31	3	0	2	0	0	0	0	71	6	0	2	0	2	0
5:40 PM	3	34	3	1	1	0	0	0	0	66	2	2	5	0	4	0
5:45 PM	4	36	4	3	1	0	1	0	0	56	1	1	3	0	1	0
5:50 PM	3	38	1	2	2	0	2	0	0	68	2	0	5	0	0	0
5:55 PM	0	50	3	2	1	1	0	0	1	54	2	0	7	0	1	0
Total	49	938	51	39	59	2	16	1	15	1540	33	17	93	0	46	1

15 Minute Volumes

15	7	93	5	8	10	0	3	0	2	175	2	1	6	0	5	0
30	3	118	6	2	4	0	1	0	2	170	3	2	11	0	4	0
45	5	112	5	2	7	0	1	0	0	182	2	3	13	0	3	1
60	10	134	8	10	8	0	3	0	2	197	6	3	13	0	9	0
75	5	132	6	0	13	1	1	0	4	240	2	1	8	0	6	0
90	5	124	5	9	9	0	2	1	3	205	2	4	12	0	9	0
105	7	101	8	1	4	0	2	0	1	193	11	2	15	0	8	0
120	7	124	8	7	4	1	3	0	1	178	5	1	15	0	2	0

Appendix B

Signal Timing Plans from SCDOT and City of Clemson

0 + Key			Phase + Key					Phase				
FUNCTION	KEY	12345678	FUNCTION	KEY	Ph 1	Ph 2	Ph 3	Ph 4	Ph 5	Ph 6	Ph 7	Ph 8
Vehicle Recall	0	2 6	Max I	0	12	30	20	0	0	30	0	20
Ped Recall	1		Max II/HFDW	1	0	0	0	0	0	0	0	0
Red Lock	2		Walk	2	0	7	0	7	0	0	0	7
Yellow Lock	3	2 6	Flashing DW	3	0	29	0	23	0	0	0	23
Permits	4	123 6 8	Max Initial	4	0	0	0	0	0	0	0	0
Ped Phases	5	2 8	Min Green	5	3	12	4	0	0	30	0	4
Lead Phases	6	1 3 5 7	TBR	6	0	0	0	0	0	0	0	0
Double Entry	7	2 6	TTR	7	0	0	0	0	0	0	0	0
Sequential Timing	8		Observe Gap	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Startup Green	9		Passage	9	3.0	2.0	3.0	0.0	0.0	2.0	0.0	2.0
Overlap A	A		Min Gap	A	3.0	2.0	3.0	0.0	0.0	2.0	0.0	2.0
Overlap B	B		Added Actuation	B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Overlap C	C		Yellow	C	3.6	3.6	3.6	0.0	0.0	3.6	0.0	3.6
Overlap D	D		Red Clear	D	2.3	2.3	2.3	0.0	0.0	2.3	0.0	2.3
Exclusive	E	34	Red Revert	E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Simultaneous Gap	F		Walk II	F	0	0	0	0	0	0	0	0

Figure B-1: US 93 @ Perimeter Rd Signal Timing from SCDOT

0 + Key			Phase + Key					Phase				
FUNCTION	KEY	12345678	FUNCTION	KEY	Ph 1	Ph 2	Ph 3	Ph 4	Ph 5	Ph 6	Ph 7	Ph 8
Vehicle Recall	0	2 6	Max I	0	16	35	30	25	30	35	30	30
Ped Recall	1		Max II/HFDW	1	0	0	30	0	30	0	30	30
Red Lock	2		Walk	2	0	0	7	0	7	0	7	7
Yellow Lock	3		Flashing DW	3	0	0	20	0	20	0	20	20
Permits	4	12 4 6	Max Initial	4	0	0	20	0	20	0	20	20
Ped Phases	5		Min Green	5	4	30	10	8	10	30	10	10
Lead Phases	6	1 3 5 7	TBR	6	0	0	10	0	10	0	10	10
Double Entry	7	2 6	TTR	7	0	0	10	0	10	0	10	10
Sequential Timing	8		Observe Gap	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Startup Green	9	2 6	Passage	9	3.0	4.0	3.0	4.0	3.0	4.0	3.0	3.0
Overlap A	A		Min Gap	A	3.0	4.0	3.0	4.0	3.0	4.0	3.0	3.0
Overlap B	B		Added Actuation	B	0.0	0.0	1.5	0.0	1.5	0.0	1.5	1.5
Overlap C	C		Yellow	C	4.0	4.0	5.0	4.0	5.0	4.0	5.0	5.0
Overlap D	D		Red Clear	D	1.0	1.5	1.0	1.5	1.0	1.5	1.0	1.0
Exclusive	E		Red Revert	E	0.0	0.0	5.0	0.0	5.0	0.0	5.0	5.0
Simultaneous Gap	F		Walk II	F	0	0	0	0	0	0	0	0

Figure B-2: US 93 @ Williamson Rd Signal Timing from SCDOT

0 + Key			Phase + Key					Phase				
FUNCTION	KEY	12345678	FUNCTION	KEY	Ph 1	Ph 2	Ph 3	Ph 4	Ph 5	Ph 6	Ph 7	Ph 8
Vehicle Recall	0	2 6	Max I	0	30	30	30	25	15	30	30	30
Ped Recall	1		Max II/HFDW	1	30	0	30	0	0	0	30	30
Red Lock	2		Walk	2	7	0	7	0	0	0	7	7
Yellow Lock	3	2 6	Flashing DW	3	20	0	20	0	0	0	20	20
Permits	4	2 456 8	Max Initial	4	20	0	20	0	0	0	20	20
Ped Phases	5	8	Min Green	5	10	30	10	25	6	30	10	10
Lead Phases	6	1 3 5 7	TBR	6	10	0	10	0	0	0	10	10
Double Entry	7	2 6	TTR	7	10	0	10	0	0	0	10	10
Sequential Timing	8		Observe Gap	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Startup Green	9	2 6	Passage	9	3.0	0.0	3.0	0.0	4.0	0.0	3.0	3.0
Overlap A	A		Min Gap	A	3.0	0.0	3.0	0.0	0.0	0.0	3.0	3.0
Overlap B	B		Added Actuation	B	1.5	0.0	1.5	0.0	0.0	0.0	1.5	1.5
Overlap C	C		Yellow	C	5.0	3.0	5.0	3.0	3.0	3.0	5.0	5.0
Overlap D	D		Red Clear	D	1.0	3.0	1.0	3.0	3.0	3.0	1.0	1.0
Exclusive	E	8	Red Revert	E	5.0	0.0	5.0	0.0	0.0	0.0	5.0	5.0
Simultaneous Gap	F		Walk II	F	0	0	0	0	0	0	0	0

Figure B-3: US 93 @ College Avenue Signal Timing from SCDOT

0 + Key			Phase + Key					Phase				
FUNCTION	KEY	12345678	FUNCTION	KEY	Ph 1	Ph 2	Ph 3	Ph 4	Ph 5	Ph 6	Ph 7	Ph 8
Vehicle Recall	0	2 6	Max I	0	30	40	20	25	30	30	30	30
Ped Recall	1		Max II/HFDW	1	30	0	0	0	30	30	30	30
Red Lock	2		Walk	2	7	0	0	10	7	7	7	7
Yellow Lock	3	2 6	Flashing DW	3	20	0	0	15	20	20	20	20
Permits	4	234 6	Max Initial	4	20	0	0	0	20	20	20	20
Ped Phases	5	4	Min Green	5	10	35	3	4	10	10	10	10
Lead Phases	6	1 3 5 7	TBR	6	10	0	0	0	10	10	10	10
Double Entry	7	2 6	TTR	7	10	0	0	0	10	10	10	10
Sequential Timing	8		Observe Gap	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Startup Green	9	2 6	Passage	9	3.0	3.0	3.0	1.5	3.0	3.0	3.0	3.0
Overlap A	A		Min Gap	A	3.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0
Overlap B	B		Added Actuation	B	1.5	0.0	0.0	0.0	1.5	1.5	1.5	1.5
Overlap C	C		Yellow	C	5.0	4.0	4.0	3.0	5.0	5.0	5.0	5.0
Overlap D	D		Red Clear	D	1.0	1.5	1.5	1.0	1.0	1.0	1.0	1.0
Exclusive	E		Red Revert	E	5.0	0.0	0.0	0.0	5.0	5.0	5.0	5.0
Simultaneous Gap	F		Walk II	F	0	0	0	0	0	0	0	0

Figure B-4: US 93 @ Parkway/Calhoun Dr. Signal Timing from SCDOT

0 + Key			Phase + Key						Phase			
FUNCTION	KEY	12345678	FUNCTION	KEY	Ph 1	Ph 2	Ph 3	Ph 4	Ph 5	Ph 6	Ph 7	Ph 8
Vehicle Recall	0	2 6	Max I	0	40	40	20	25	20	40	30	30
Ped Recall	1		Max II/HFDW	1	0	0	0	0	0	0	30	30
Red Lock	2		Walk	2	0	0	0	7	0	7	7	7
Yellow Lock	3	2 6	Flashing DW	3	0	0	0	12	0	15	20	20
Permits	4	23456	Max Initial	4	0	0	0	0	0	0	20	20
Ped Phases	5	4 6	Min Green	5	16	16	4	6	4	16	10	10
Lead Phases	6	1 3 5 7	TBR	6	0	0	0	0	0	0	10	10
Double Entry	7	2 6	TTR	7	0	0	0	0	0	0	10	10
Sequential Timing	8		Observe Gap	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Startup Green	9	2 6	Passage	9	4.0	4.0	3.0	3.0	2.0	4.0	3.0	3.0
Overlap A	A		Min Gap	A	4.0	4.0	3.0	3.0	2.0	4.0	3.0	3.0
Overlap B	B		Added Actuation	B	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.5
Overlap C	C		Yellow	C	3.6	3.6	3.5	3.5	3.6	3.6	5.0	5.0
Overlap D	D		Red Clear	D	2.3	2.3	2.7	2.7	2.3	2.3	1.0	1.0
Exclusive	E		Red Revert	E	0.0	0.0	0.0	0.0	0.0	0.0	5.0	5.0
Simultaneous Gap	F		Walk II	F	0	0	0	0	0	0	0	0

Figure B-5: US 93 @ Cherry Rd Signal Timing from SCDOT

Phase One								
			Lane (No.)					
Interval	Timing (mm:ss)	Description	NBLT (1)	NBTH (2)	SBLT (3)	SBTH (4)	EBTH (5)	WBTH (6)
1	0:20	East/West Permissive Phase	R	R	R	R	G	G
2	0:03	East/West Change Interval	R	R	R	R	Y	Y
3	0:02	All Red Phase	R	R	R	R	R	R
4	0:06	North/South Protected Left Turn	G	R	G	R	R	R
5	0:03	North/South Clearance Interval	Y	R	Y	R	R	R
6	0:43	North/South Permissive Phase		G		G	R	R
7	0:03	North/South Change Interval		Y		Y	R	R
8	0:02	All Red Phase	R	R	R	R	R	R
Total:	1:22							

Phase Two								
			Lane (No.)					
Interval	Timing (mm:ss)	Description	NBLT (1)	NBTH (2)	SBLT (3)	SBTH (4)	EBTH (5)	WBTH (6)
1	0:20	East/West Permissive Phase	R	R	R	R	G	G
2	0:03	East/West Change Interval	R	R	R	R	Y	Y
3	0:02	All Red Phase	R	R	R	R	R	R
4	0:06	North/South Protected Left Turn	G	R	G	R	R	R
5	0:03	North/South Clearance Interval	Y	R	Y	R	R	R
6	0:43	North/South Permissive Phase		G		G	R	R
7	0:03	North/South Change Interval		Y		Y	R	R
8	0:02	All Red Phase	R	R	R	R	R	R
9	0:25	All Red/Protected Pedestrian Crossing	R	R	R	R	R	R
Total:	1:47							

Figure B-6: College Ave @ Keith St Signal Timing from City of Clemson

0 + Key			Phase + Key					Phase				
FUNCTION	KEY	12345678	FUNCTION	KEY	Ph 1	Ph 2	Ph 3	Ph 4	Ph 5	Ph 6	Ph 7	Ph 8
Vehicle Recall	0	2 6	Max I	0	7	35	30	15	30	35	30	15
Ped Recall	1		Max II/HFDW	1	0	0	30	0	30	0	30	0
Red Lock	2		Walk	2	0	7	7	7	7	7	7	7
Yellow Lock	3		Flashing DW	3	0	12	20	12	20	12	20	12
Permits	4	12 4 6 8	Max Initial	4	0	0	20	0	20	0	20	0
Ped Phases	5	2 4 6 8	Min Green	5	4	15	10	4	10	15	10	4
Lead Phases	6	1 3 5 7	TBR	6	0	0	10	0	10	0	10	0
Double Entry	7	2 4 6 8	TTR	7	0	0	10	0	10	0	10	0
Sequential Timing	8		Observe Gap	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Startup Green	9	2 6	Passage	9	1.0	2.0	3.0	1.5	3.0	2.0	3.0	1.5
Overlap A	A		Min Gap	A	1.0	2.0	3.0	1.5	3.0	2.0	3.0	1.5
Overlap B	B		Added Actuation	B	0.0	0.0	1.5	0.0	1.5	0.0	1.5	0.0
Overlap C	C		Yellow	C	3.6	3.6	5.0	3.6	5.0	3.6	5.0	3.6
Overlap D	D		Red Clear	D	2.4	2.4	1.0	2.4	1.0	2.4	1.0	2.4
Exclusive	E		Red Revert	E	0.0	0.0	5.0	0.0	5.0	0.0	5.0	0.0
Simultaneous Gap	F		Walk II	F	0	0	0	0	0	0	0	0

Figure B-7: College Avenue @ Edgewood Dr Signal Timing from SCDOT

Appendix C

Existing Network VISSIM Screenshots and RBC Signal Timing

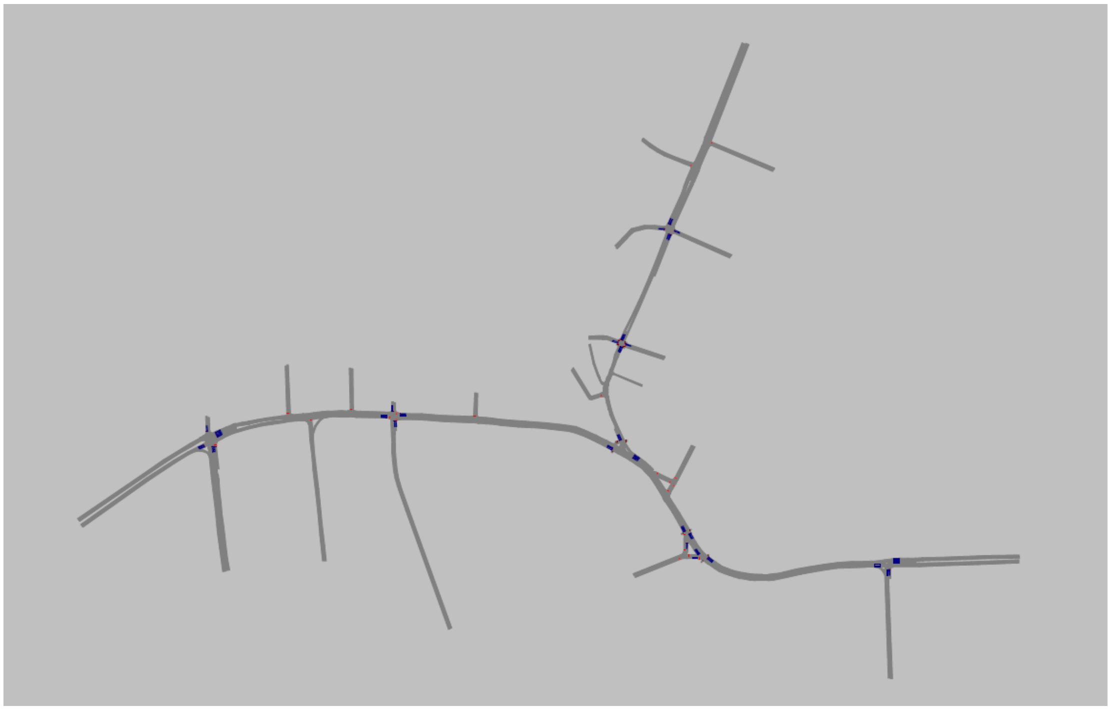


Figure C-1: Network Layout

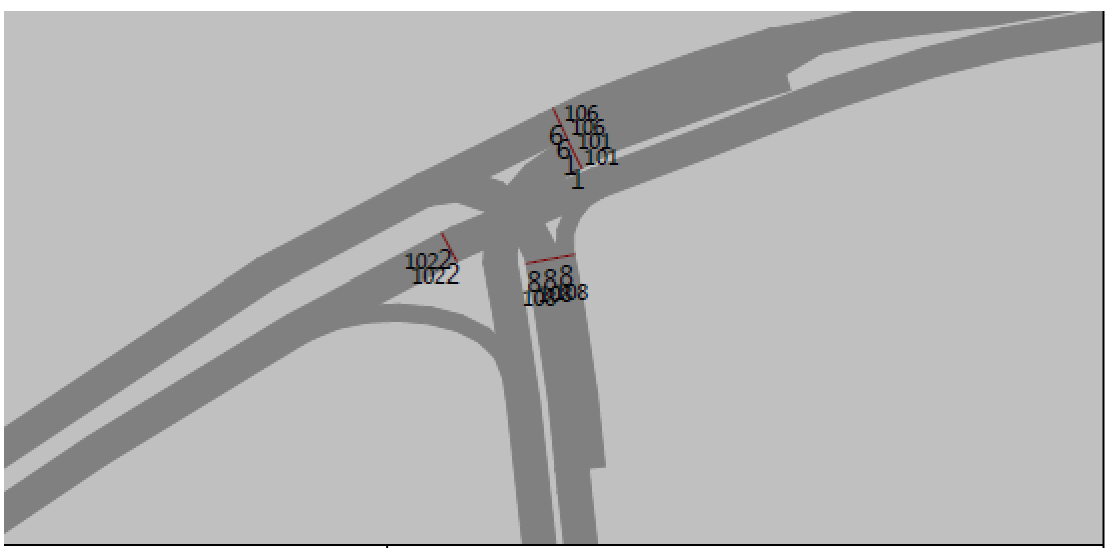


Figure C-2: US 93 @ Perimeter Rd.

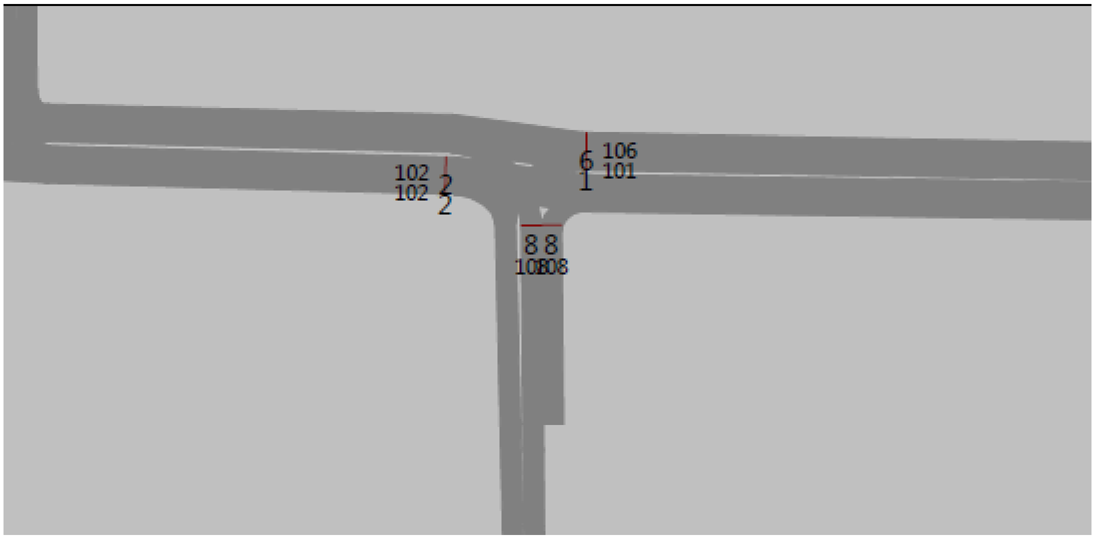


Figure C-3: US 93 @ Williamson Rd.

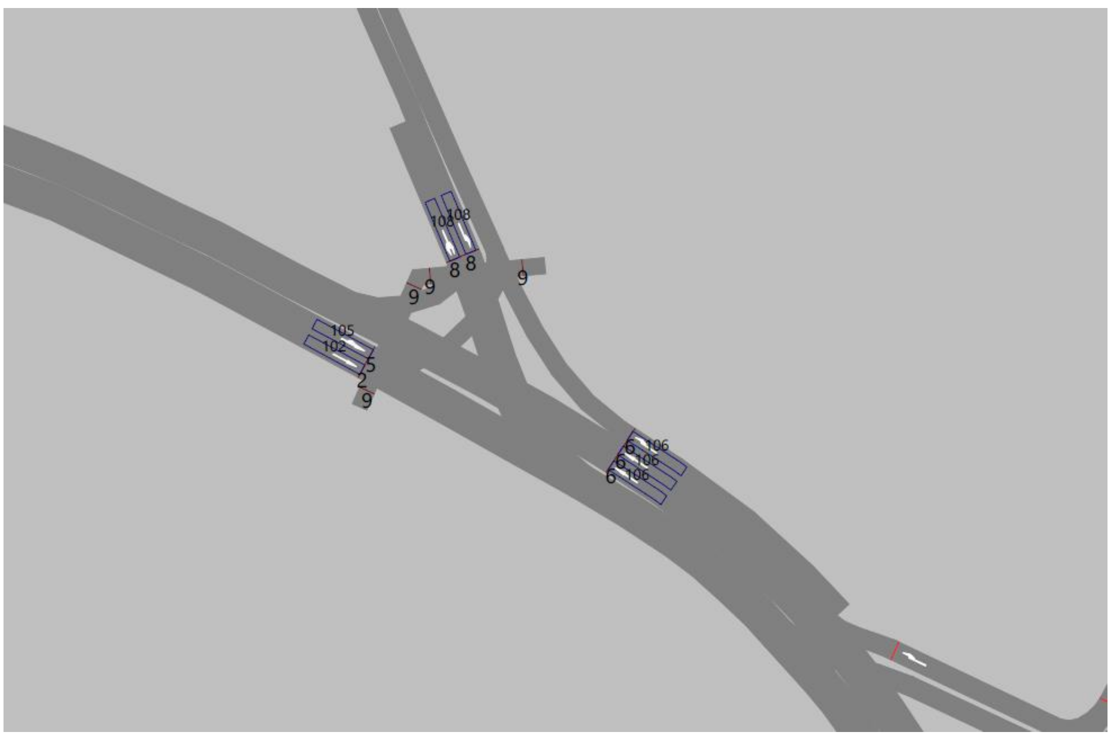


Figure C-4: US 93 @ College Ave.

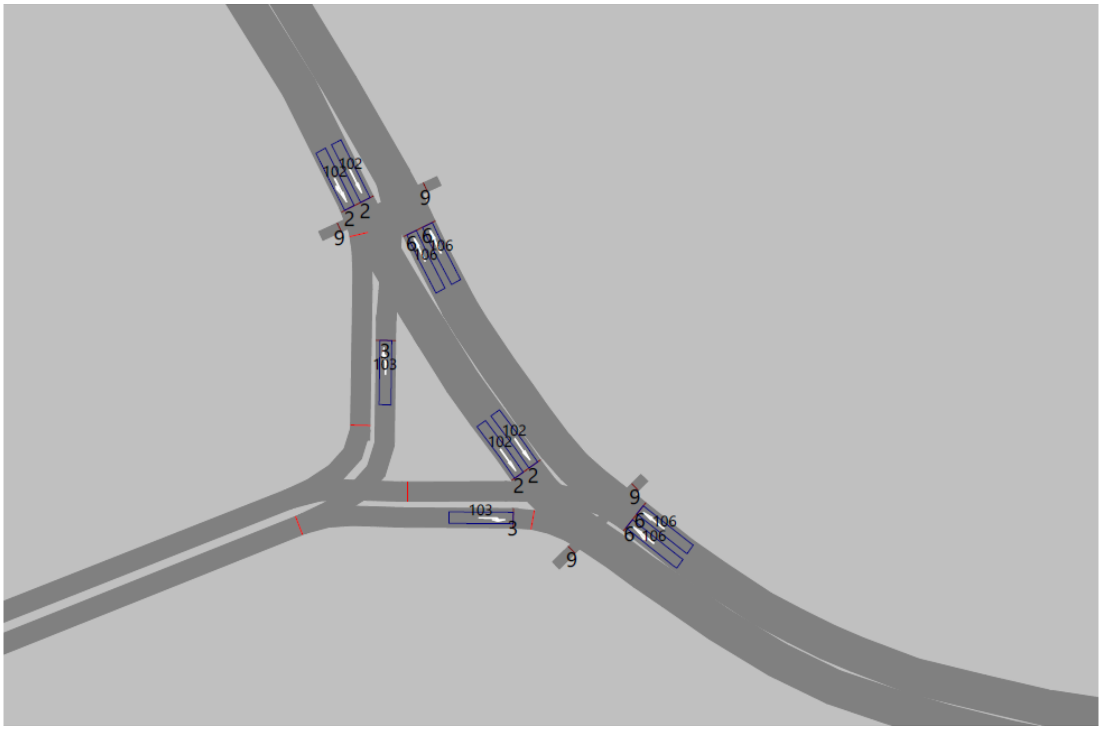


Figure C-5: US 93 @ Parkway Dr./Calhoun Dr.

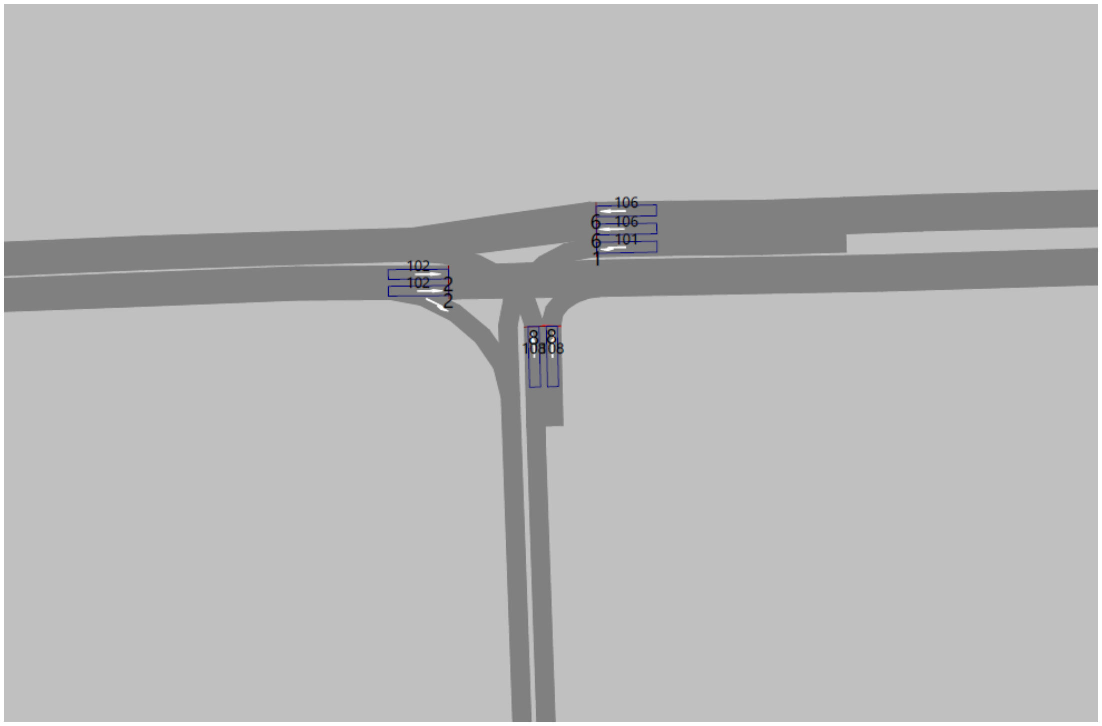


Figure C-6: US 93 @ Cherry Rd.

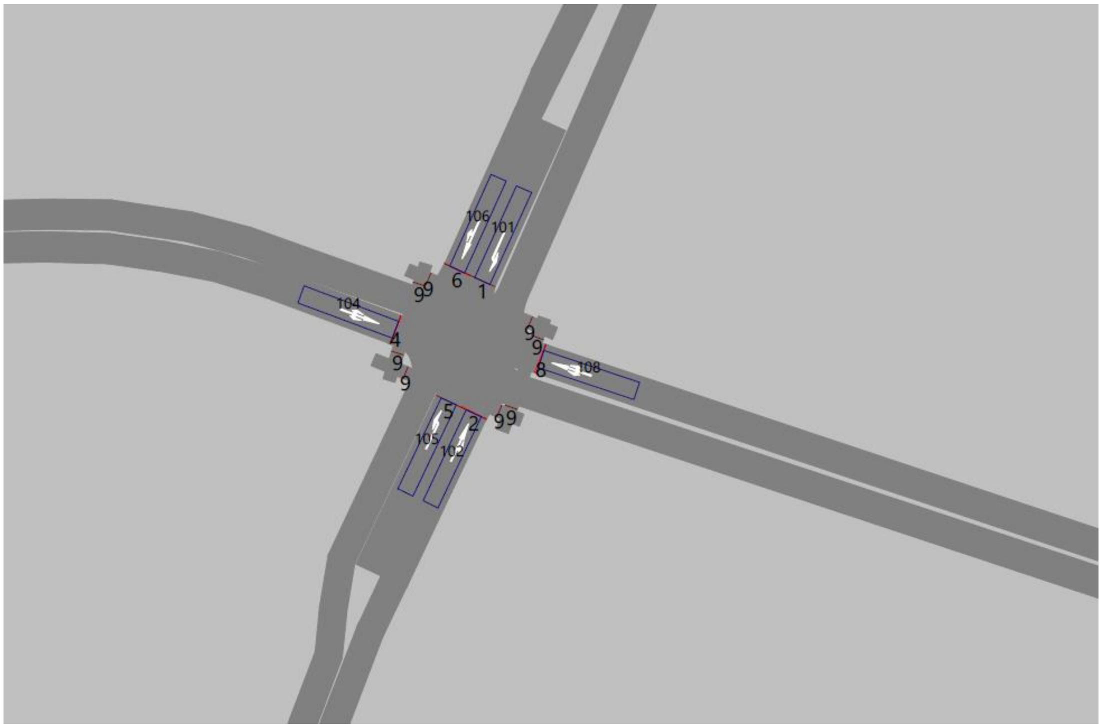


Figure C-7: College Ave. @ Keith St.

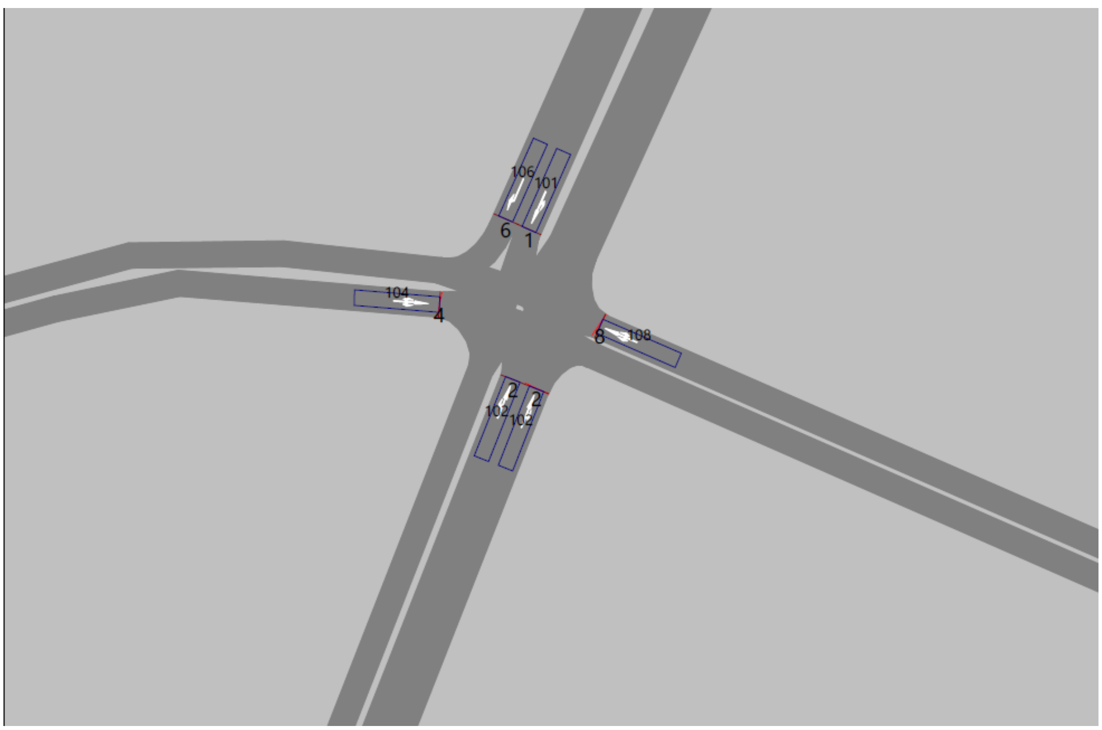


Figure C-8: College Ave. @ Edgewood Ave.

Offset Reference : LeadGreen
Transition Mode : Best

Basic:

SG Number	1	2	6	8											
SG Name	WBL	EBT	WBT	NB											
Min Green	3	12	30	4											
Veh Extension	3	2	2	2											
Max 1	12	30	30	20											
Yellow	3.6	3.6	3.6	3.6											
Red Clearance	2.4	2.4	2.4	2.4											
Ped SG Number															
Walk															
Ped Clear (FDW)															
Start Up	☐	■	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Min Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ped Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soft Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
NSE Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dual Entry	☐	■	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Speed															

Sequence

Ring 1	1	2	8
Ring 2	6		
Ring 3			
Ring 4			

Vehicle Detectors

Detector Number	101	102	106	108			
Delay							
Extend							
Carry Over							
Queue Limit							
Detector Mode	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect
Added Initial Mode	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Call	1	2	6	8			
Yellow Lock							
Red Lock							
Extend SGs	1	2	6	8			
XSwitch SGs							
CallID							
Subtracted CallID							

Figure C-9: VISSIM Timing Inputs for US 93 @ Perimeter Rd.

Offset Reference :	LeadGreen
Transition Mode :	Best

Basic:

SG Number	1	2	6	8											
SG Name	WBL	EBT	WBT	NB											
Min Green	4	30	30	10											
Veh Extension	3	4	4	3											
Max 1	16	35	35	30											
Yellow	4	4	4	5											
Red Clearance	1	1.5	1.5	1											
Ped SG Number															
Walk															
Ped Clear (FDW)															
Start Up	☐	■	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Min Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ped Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soft Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
NSE Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dual Entry	☐	■	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Speed															

Sequence

Ring 1	1	2	8
Ring 2	6		
Ring 3			
Ring 4			

Vehicle Detectors

Detector Number	101	102	106	108			
Delay							
Extend							
Carry Over							
Queue Limit							
Detector Mode	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect
Added Initial Mode	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Call	1	2	6	8			
Yellow Lock							
Red Lock							
Extend SGs	1	2	6	8			
XSwitch SGs							
CallID							
Subtracted CallID							

Figure C-10: VISSIM Timing Inputs for US 93 @ Williamson Rd.

Offset Reference : LeadGreen
Transition Mode : Best

Basic

SG Number	2	5	6	8	9										
SG Name	EBT	EBL	WBT	SB	PED										
Min Green	30	6	30	10	27										
Veh Extension	3	4		3											
Max 1	30	15	30	30	27										
Yellow	3	3	3	5	3										
Red Clearance	3	3	3	1	1										
Ped SG Number															
Walk															
Ped Clear (FDW)															
Start Up	■	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Min Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Recall	☐	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ped Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soft Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
NSE Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dual Entry	■	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Speed															

Sequence

Ring 1		2	8	9
Ring 2	5	6		
Ring 3				
Ring 4				

Vehicle Detectors

Detector Number	102	105	106	108			
Delay							
Extend							
Carry Over							
Queue Limit							
Detector Mode	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect
Added Initial Mode	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Call	2	5	6	8			
Yellow Lock							
Red Lock							
Extend SGs	2	5	6	8			
XSwitch SGs							
CallID							
Subtracted CallID							

Figure C-11: VISSIM Timing Inputs for US 93 @ College Ave.

Offset Reference : LeadGreen
Transition Mode : Best

Basic

SG Number	2	3	6	9											
SG Name	EB	NB	WB	PED											
Min Green	35	3	10	25											
Veh Extension	3	3	3												
Max 1	40	20	30	25											
Yellow	4	4	5	3											
Red Clearance	1.5	1.5	1	1											
Ped SG Number															
Walk															
Ped Clear (FDW)															
Start Up	■	□	■	□	□	□	□	□	□	□	□	□	□	□	□
Min Recall	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Max Recall	□	□	□	■	□	□	□	□	□	□	□	□	□	□	□
Ped Recall	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Soft Recall	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
NSE Max Recall	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Dual Entry	■	□	■	□	□	□	□	□	□	□	□	□	□	□	□
Max Speed															

Sequence

Ring 1	2	3	9
Ring 2	6		
Ring 3			
Ring 4			

Vehicle Detectors

Detector Number	102	103	106				
Delay							
Extend							
Carry Over							
Queue Limit							
Detector Mode	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect
Added Initial Mode	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Call	2	3	6				
Yellow Lock							
Red Lock							
Extend SGs	2	3	6				
XSwitch SGs							
CallID							
Subtracted CallID							

Figure C-12: VISSIM Timing Inputs for US 93 @ Parkway Dr./Calhoun Dr.

Offset Reference : LeadGreen
Transition Mode : Best

Basic

SG Number	1	2	6	8											
SG Name	WBL	EBT	WBT	SB											
Min Green	4	16	16	4											
Veh Extension	2	4	4	4											
Max 1	20	40	40	25											
Yellow	3.6	3.6	3.6	3.6											
Red Clearance	2.4	2.4	2.4	2.4											
Ped SG Number															
Walk															
Ped Clear (FDW)															
Start Up	☐	■	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Min Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ped Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soft Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
NSE Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dual Entry	☐	■	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Speed															

Sequence

Ring 1	1	6	8
Ring 2		2	
Ring 3			
Ring 4			

Vehicle Detectors

Detector Number	101	102	106	108			
Delay							
Extend							
Carry Over							
Queue Limit							
Detector Mode	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect
Added Initial Mode	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Call	1	2	6	8			
Yellow Lock							
Red Lock							
Extend SGs	1	2	6	8			
XSwitch SGs							
CallID							
Subtracted CallID							

Figure C-13: Figure C-9: VISSIM Timing Inputs for US 93 @ Cherry Rd.

Offset Reference : LeadGreen
Transition Mode : Best

Basic

SG Number	1	2	4	5	6	8	9								
SG Name	NBL	SB	EB	SBL	NB	WB	PED								
Min Green															
Veh Extension															
Max 1	6	43	20	6	43	20	20								
Yellow	3	3	3	3	3	3	3								
Red Clearance	2	2	2	2	2	2	2								
Ped SG Number															
Walk															
Ped Clear (FDW)															
Start Up	☐	■	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐
Min Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Recall	☐	☐	■	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	☐	☐
Ped Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soft Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
NSE Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dual Entry	☐	■	■	☐	■	☐	■	☐	☐	☐	☐	☐	☐	☐	☐
Max Speed															

Sequence

Ring 1	1	2	4	9
Ring 2	5	6	8	
Ring 3				
Ring 4				

Vehicle Detectors

Detector Number	101	102	104	105	106	108	
Delay							
Extend							
Carry Over							
Queue Limit							
Detector Mode	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect
Added Initial Mode	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Call	1	2	4	5	6	8	
Yellow Lock							
Red Lock							
Extend SGs	1	2	4	5	6	8	
XSwitch SGs							
CallID							
Subtracted CallID							

Figure C-14: VISSIM Timing Inputs for College Ave. @ Keith St.

Offset Reference : LeadGreen
Transition Mode : Best

Basic

SG Number	1	2	4	6	8										
SG Name	SBL	NB	EB	NB	WB										
Min Green	4	15	4	15	4										
Veh Extension	1	2	1.5	2	1.5										
Max 1	7	35	15	35	15										
Yellow	3.6	3.6	3.6	3.6	3.6										
Red Clearance	2.4	2.4	2.4	2.4	2.4										
Ped SG Number															
Walk															
Ped Clear (FDW)															
Start Up	☐	■	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Min Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ped Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soft Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
NSE Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dual Entry	☐	■	■	■	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Speed															

Sequence

Ring 1	1	2	4
Ring 2		6	8
Ring 3			
Ring 4			

Vehicle Detectors

Detector Number	101	102	104	106	108		
Delay							
Extend							
Carry Over							
Queue Limit							
Detector Mode	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect
Added Initial Mode	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Call	1	2	4	6	8		
Yellow Lock							
Red Lock							
Extend SGs	1	2	4	6	8		
XSwitch SGs							
CallID							
Subtracted CallID							

Figure C-15: VISSIM Timing Inputs for College Ave. @ Edgewood Ave.

Appendix D

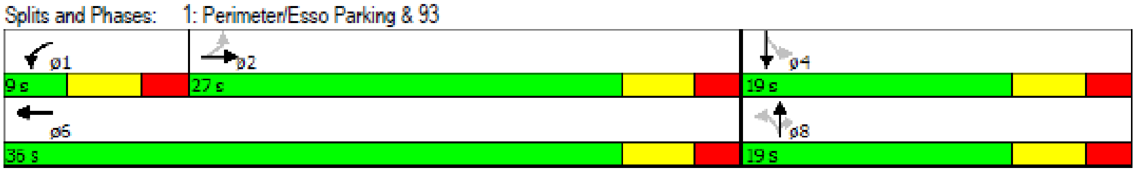
Synchro Reports – Optimized and Coordinated Scenarios

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	222	283	72	263	0	390	2	186	2	0	1
Future Volume (vph)	1	222	283	72	263	0	390	2	186	2	0	1
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width (ft)	12	12	12	12	12	12	12	12	12	12	12	12
Storage Length (ft)	0		0	225		0	0		190	0		0
Storage Lanes	0		0	2		0	1		1	0		0
Taper Length (ft)	25			25			25			25		
Right Turn on Red			Yes			Yes			Yes			Yes
Link Speed (mph)		25			25			35			15	
Link Distance (ft)		432			659			734			143	
Travel Time (s)		11.8			18.0			14.3			6.5	
Turn Type	Perm	NA		Prot	NA		Perm	NA	Perm	Perm	NA	
Protected Phases		2		1	6			8			4	
Permitted Phases	2						8		8	4		
Detector Phase	2	2		1	6		8	8	8	4	4	
Switch Phase												
Minimum Initial (s)	12.0	12.0		3.0	30.0		4.0	4.0	4.0	4.0	4.0	
Minimum Split (s)	18.0	18.0		9.0	36.0		10.0	10.0	10.0	10.0	10.0	
Total Split (s)	27.0	27.0		9.0	36.0		19.0	19.0	19.0	19.0	19.0	
Total Split (%)	49.1%	49.1%		16.4%	65.5%		34.5%	34.5%	34.5%	34.5%	34.5%	
Maximum Green (s)	21.1	21.1		3.1	30.1		13.1	13.1	13.1	13.1	13.1	
Yellow Time (s)	3.6	3.6		3.6	3.6		3.6	3.6	3.6	3.6	3.6	
All-Red Time (s)	2.3	2.3		2.3	2.3		2.3	2.3	2.3	2.3	2.3	
Lost Time Adjust (s)		0.0		0.0	0.0		0.0	0.0	0.0		0.0	
Total Lost Time (s)		5.9		5.9	5.9		5.9	5.9	5.9		5.9	
Lead/Lag	Lag	Lag		Lead								
Lead-Lag Optimize?	Yes	Yes		Yes								
Vehicle Extension (s)	2.0	2.0		3.0	2.0		2.0	2.0	2.0	3.0	3.0	
Recall Mode	Min	Min		None	Min		None	None	None	None	None	
Walk Time (s)	7.0	7.0					7.0	7.0	7.0			
Flash Dont Walk (s)	29.0	29.0					17.0	17.0	17.0			
Pedestrian Calls (#/hr)	5	5					0	0	0			

Intersection Summary

Area Type: Other
Cycle Length: 55
Actuated Cycle Length: 56.4
Natural Cycle: 55
Control Type: Actuated-Uncoordinated

Splits and Phases: 1: Perimeter/Esso Parking & 93

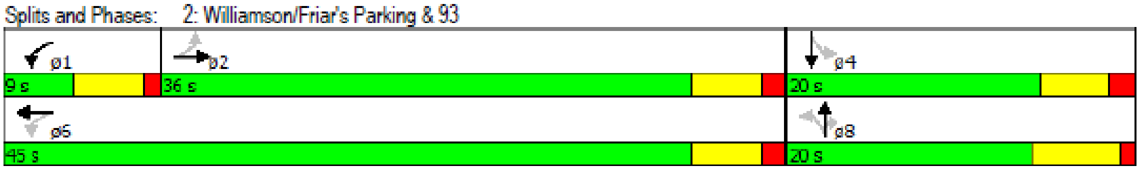


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	342	93	173	232	2	135	0	370	3	0	0
Future Volume (vph)	1	342	93	173	232	2	135	0	370	3	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	0		100	0		0
Storage Lanes	0		0	0		0	0		1	0		0
Taper Length (ft)	25			25			25			25		
Right Turn on Red			Yes			Yes			Yes			Yes
Link Speed (mph)		25			25			25			15	
Link Distance (ft)		326			649			749			105	
Travel Time (s)		8.9			17.7			20.4			4.8	
Turn Type	Perm	NA		pm+pt	NA		Perm	NA	Perm	Perm	NA	
Protected Phases		2		1	6			8			4	
Permitted Phases	2			6			8		8	4		
Detector Phase	2	2		1	6		8	8	8	4	4	
Switch Phase												
Minimum Initial (s)	30.0	30.0		4.0	30.0		10.0	10.0	10.0	8.0	8.0	
Minimum Split (s)	35.5	35.5		9.0	35.5		16.0	16.0	16.0	13.5	13.5	
Total Split (s)	36.0	36.0		9.0	45.0		20.0	20.0	20.0	20.0	20.0	
Total Split (%)	55.4%	55.4%		13.8%	69.2%		30.8%	30.8%	30.8%	30.8%	30.8%	
Maximum Green (s)	30.5	30.5		4.0	39.5		14.0	14.0	14.0	14.5	14.5	
Yellow Time (s)	4.0	4.0		4.0	4.0		5.0	5.0	5.0	4.0	4.0	
All-Red Time (s)	1.5	1.5		1.0	1.5		1.0	1.0	1.0	1.5	1.5	
Lost Time Adjust (s)		0.0			0.0			0.0	0.0		0.0	
Total Lost Time (s)		5.5			5.5			6.0	6.0		5.5	
Lead/Lag	Lag	Lag		Lead								
Lead-Lag Optimize?	Yes	Yes		Yes								
Vehicle Extension (s)	4.0	4.0		3.0	4.0		3.0	3.0	3.0	4.0	4.0	
Minimum Gap (s)	4.0	4.0		3.0	4.0		3.0	3.0	3.0	4.0	4.0	
Time Before Reduce (s)	0.0	0.0		0.0	0.0		10.0	10.0	10.0	0.0	0.0	
Time To Reduce (s)	0.0	0.0		0.0	0.0		10.0	10.0	10.0	0.0	0.0	
Recall Mode	Min	Min		None	Min		None	None	None	None	None	
Walk Time (s)	7.0	7.0			7.0		7.0	7.0	7.0			
Flash Dont Walk (s)	20.0	20.0			20.0		20.0	20.0	20.0			
Pedestrian Calls (#/hr)	5	5			0		5	5	5			

Intersection Summary

Area Type: Other
Cycle Length: 65
Actuated Cycle Length: 56.1
Natural Cycle: 65
Control Type: Actuated-Uncoordinated

Splits and Phases: 2: Williamson/Friar's Parking & 93

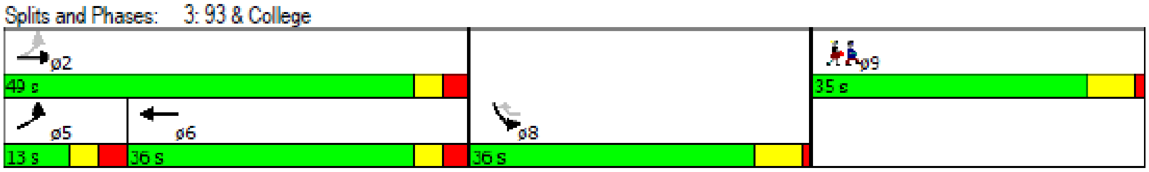


Lane Group	EBL	EBT	WBT	WBR	SBL	SBR	ø9
Lane Configurations							
Traffic Volume (vph)	240	530	332	347	284	120	
Future Volume (vph)	240	530	332	347	284	120	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	
Storage Length (ft)	0			225	0	150	
Storage Lanes	1			1	2	1	
Taper Length (ft)	25				25		
Right Turn on Red				No		No	
Link Speed (mph)		25	25		25		
Link Distance (ft)		1228	295		485		
Travel Time (s)		33.5	8.0		13.2		
Turn Type	pm+pt	NA	NA	custom	Prot		
Protected Phases	5	2	6		8		9
Permitted Phases	2			8			
Detector Phase	5	2	6	8	8		
Switch Phase							
Minimum Initial (s)	6.0	30.0	30.0	10.0	10.0		27.0
Minimum Split (s)	12.0	36.0	36.0	16.0	16.0		35.0
Total Split (s)	13.0	49.0	36.0	36.0	36.0		35.0
Total Split (%)	10.8%	40.8%	30.0%	30.0%	30.0%		29%
Maximum Green (s)	7.0	43.0	30.0	30.0	30.0		29.0
Yellow Time (s)	3.0	3.0	3.0	5.0	5.0		5.0
All-Red Time (s)	3.0	3.0	3.0	1.0	1.0		1.0
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0		
Total Lost Time (s)	6.0	6.0	6.0	6.0	6.0		
Lead/Lag	Lead		Lag				
Lead-Lag Optimize?	Yes		Yes				
Vehicle Extension (s)	4.0	0.2	0.2	0.2	0.2		3.0
Minimum Gap (s)	4.0	0.2	0.2	3.0	3.0		3.0
Time Before Reduce (s)	0.0	0.0	0.0	10.0	10.0		0.0
Time To Reduce (s)	0.0	0.0	0.0	10.0	10.0		0.0
Recall Mode	None	Min	Min	None	None		None
Walk Time (s)							7.0
Flash Dont Walk (s)							20.0
Pedestrian Calls (#/hr)							100

Intersection Summary

Area Type: CBD
Cycle Length: 120
Actuated Cycle Length: 118
Natural Cycle: 120
Control Type: Actuated-Uncoordinated

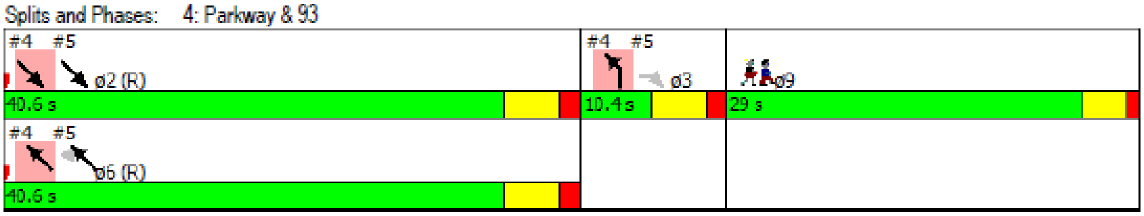
Splits and Phases: 3: 93 & College



Lane Group	NBL	NBR	SET	SER	NWL	NWT	ø9
Lane Configurations							
Traffic Volume (vph)	78	0	655	121	0	627	
Future Volume (vph)	78	0	655	121	0	627	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	
Right Turn on Red		Yes		Yes			
Link Speed (mph)	15		25			25	
Link Distance (ft)	205		229			270	
Travel Time (s)	9.3		6.2			7.4	
Turn Type	Prot		NA			NA	
Protected Phases	3		2			6	9
Permitted Phases							
Detector Phase	3		2			6	
Switch Phase							
Minimum Initial (s)	3.0		35.0			35.0	25.0
Minimum Split (s)	8.5		40.5			40.5	29.0
Total Split (s)	10.4		40.6			40.6	29.0
Total Split (%)	13.0%		50.8%			50.8%	36%
Maximum Green (s)	4.9		35.1			35.1	25.0
Yellow Time (s)	4.0		4.0			4.0	3.0
All-Red Time (s)	1.5		1.5			1.5	1.0
Lost Time Adjust (s)	0.0		0.0			0.0	
Total Lost Time (s)	5.5		5.5			5.5	
Lead/Lag							
Lead-Lag Optimize?							
Vehicle Extension (s)	3.0		3.0			3.0	1.5
Minimum Gap (s)	3.0		3.0			3.0	3.0
Time Before Reduce (s)	10.0		0.0			10.0	0.0
Time To Reduce (s)	10.0		0.0			10.0	0.0
Recall Mode	None		C-Min			C-Min	None
Walk Time (s)							7.0
Flash Dont Walk (s)							11.0
Pedestrian Calls (#/hr)							100

Intersection Summary	
Area Type:	Other
Cycle Length: 80	
Actuated Cycle Length: 80	
Offset: 0 (0%), Referenced to phase 2:SET and 6:NWT, Start of Green	
Natural Cycle: 80	
Control Type: Actuated-Coordinated	

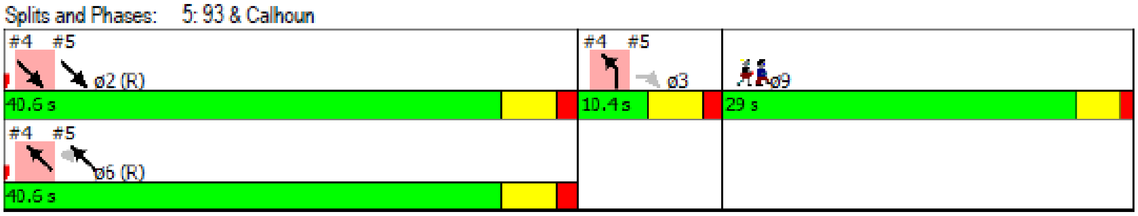
Splits and Phases: 4: Parkway & 93



Lane Group	EBL	EBR	SET	SER	NWL	NWT	ø9
Lane Configurations		↱	↑↑			↰↑	
Traffic Volume (vph)	0	71	655	0	140	627	
Future Volume (vph)	0	71	655	0	140	627	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	
Right Turn on Red		Yes		Yes			
Link Speed (mph)	15		25			25	
Link Distance (ft)	156		270			1508	
Travel Time (s)	7.1		7.4			41.1	
Turn Type		Perm	NA		Perm	NA	
Protected Phases			2			6	9
Permitted Phases		3			6		
Detector Phase		3	2		6	6	
Switch Phase							
Minimum Initial (s)		3.0	35.0		35.0	35.0	25.0
Minimum Split (s)		8.5	40.5		40.5	40.5	29.0
Total Split (s)		10.4	40.6		40.6	40.6	29.0
Total Split (%)		13.0%	50.8%		50.8%	50.8%	36%
Maximum Green (s)		4.9	35.1		35.1	35.1	25.0
Yellow Time (s)		4.0	4.0		4.0	4.0	3.0
All-Red Time (s)		1.5	1.5		1.5	1.5	1.0
Lost Time Adjust (s)		0.0	0.0			0.0	
Total Lost Time (s)		5.5	5.5			5.5	
Lead/Lag							
Lead-Lag Optimize?							
Vehicle Extension (s)		3.0	3.0		3.0	3.0	1.5
Minimum Gap (s)		3.0	3.0		3.0	3.0	3.0
Time Before Reduce (s)		10.0	0.0		10.0	10.0	0.0
Time To Reduce (s)		10.0	0.0		10.0	10.0	0.0
Recall Mode		None	C-Min		C-Min	C-Min	None
Walk Time (s)							7.0
Flash Dont Walk (s)							11.0
Pedestrian Calls (#/hr)							100

Intersection Summary
Area Type: Other
Cycle Length: 80
Actuated Cycle Length: 80
Offset: 0 (0%), Referenced to phase 2:SET and 6:NWT, Start of Green
Natural Cycle: 80
Control Type: Actuated-Coordinated

Splits and Phases: 5: 93 & Calhoun

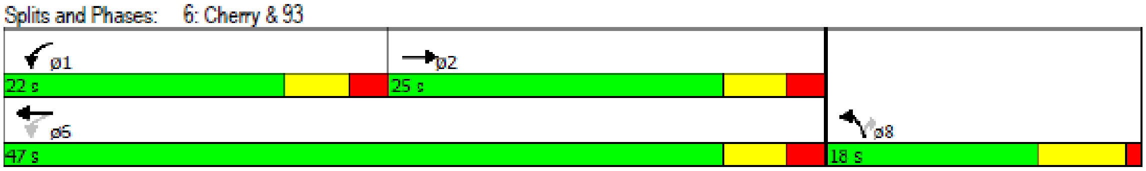


Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Volume (vph)	662	153	180	538	250	225
Future Volume (vph)	662	153	180	538	250	225
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (ft)		0	150		0	75
Storage Lanes		0	1		1	1
Taper Length (ft)			25		25	
Right Turn on Red		Yes				Yes
Link Speed (mph)	25			40	15	
Link Distance (ft)	1508			733	570	
Travel Time (s)	41.1			12.5	25.9	
Turn Type	NA		pm+pt	NA	Prot	Perm
Protected Phases	2		1	6	8	
Permitted Phases			6			8
Detector Phase	2		1	6	8	8
Switch Phase						
Minimum Initial (s)	16.0		16.0	16.0	6.0	6.0
Minimum Split (s)	22.0		22.0	22.0	12.0	12.0
Total Split (s)	25.0		22.0	47.0	18.0	18.0
Total Split (%)	38.5%		33.8%	72.3%	27.7%	27.7%
Maximum Green (s)	19.1		16.1	41.1	12.0	12.0
Yellow Time (s)	3.6		3.6	3.6	5.0	5.0
All-Red Time (s)	2.3		2.3	2.3	1.0	1.0
Lost Time Adjust (s)	0.0		0.0	0.0	0.0	0.0
Total Lost Time (s)	5.9		5.9	5.9	6.0	6.0
Lead/Lag	Lag		Lead			
Lead-Lag Optimize?	Yes		Yes			
Vehicle Extension (s)	4.0		4.0	4.0	3.0	3.0
Minimum Gap (s)	4.0		4.0	4.0	3.0	3.0
Time Before Reduce (s)	0.0		0.0	0.0	10.0	10.0
Time To Reduce (s)	0.0		0.0	0.0	10.0	10.0
Recall Mode	Min		None	Min	None	None
Walk Time (s)	7.0				7.0	7.0
Flash Dont Walk (s)	15.0				20.0	20.0
Pedestrian Calls (#/hr)	5				0	0

Intersection Summary

Area Type: Other
Cycle Length: 65
Actuated Cycle Length: 65.3
Natural Cycle: 65
Control Type: Actuated-Uncoordinated

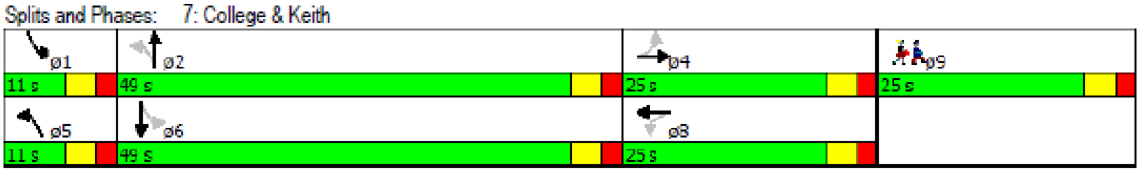
Splits and Phases: 6: Cherry & 93



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✥			✥		↰	↑		↰	↑	
Traffic Volume (vph)	59	5	70	60	6	94	43	409	35	53	327	29
Future Volume (vph)	59	5	70	60	6	94	43	409	35	53	327	29
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	50		0	50		0
Storage Lanes	0		0	0		0	1		0	1		0
Taper Length (ft)	25			25			25			25		
Right Turn on Red			Yes			Yes			Yes			Yes
Link Speed (mph)		25			25			25			25	
Link Distance (ft)		216			299			238			987	
Travel Time (s)		5.9			8.2			6.5			26.9	
Turn Type	Perm	NA		Perm	NA		pm+pt	NA		pm+pt	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8			2			6		
Detector Phase	4	4		8	8		5	2		1	6	
Switch Phase												
Minimum Initial (s)	20.0	20.0		20.0	20.0		6.0	43.0		6.0	43.0	
Minimum Split (s)	25.0	25.0		25.0	25.0		11.0	48.0		11.0	48.0	
Total Split (s)	25.0	25.0		25.0	25.0		11.0	49.0		11.0	49.0	
Total Split (%)	22.7%	22.7%		22.7%	22.7%		10.0%	44.5%		10.0%	44.5%	
Maximum Green (s)	20.0	20.0		20.0	20.0		6.0	44.0		6.0	44.0	
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
All-Red Time (s)	2.0	2.0		2.0	2.0		2.0	2.0		2.0	2.0	
Lost Time Adjust (s)		0.0			0.0		0.0	0.0		0.0	0.0	
Total Lost Time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Lead/Lag							Lead	Lag		Lead	Lag	
Lead-Lag Optimize?							Yes	Yes		Yes	Yes	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Recall Mode	None	None		None	None		None	Min		None	Min	
Walk Time (s)												
Flash Dont Walk (s)												
Pedestrian Calls (#/hr)												

Intersection Summary	
Area Type:	CBD
Cycle Length: 110	
Actuated Cycle Length: 102	
Natural Cycle: 110	
Control Type: Actuated-Uncoordinated	

Splits and Phases: 7: College & Keith



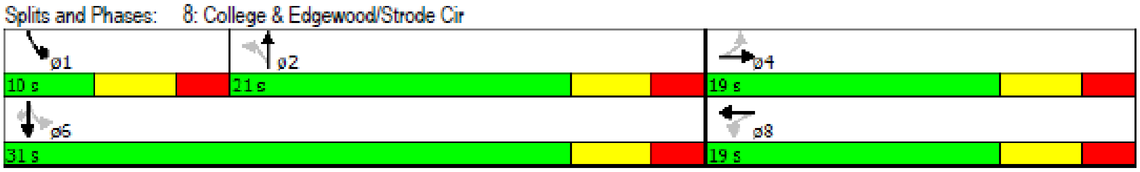
Lane Group	ø9
Lane Configurations	
Traffic Volume (vph)	
Future Volume (vph)	
Ideal Flow (vphpl)	
Storage Length (ft)	
Storage Lanes	
Taper Length (ft)	
Right Turn on Red	
Link Speed (mph)	
Link Distance (ft)	
Travel Time (s)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	20.0
Minimum Split (s)	25.0
Total Split (s)	25.0
Total Split (%)	23%
Maximum Green (s)	20.0
Yellow Time (s)	3.0
All-Red Time (s)	2.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Vehicle Extension (s)	3.0
Recall Mode	None
Walk Time (s)	7.0
Flash Dont Walk (s)	13.0
Pedestrian Calls (#/hr)	100

Intersection Summary

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	184	4	12	10	6	94	3	327	53	28	371	29
Future Volume (vph)	184	4	12	10	6	94	3	327	53	28	371	29
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	0		250	0		0
Storage Lanes	0		0	0		0	0		1	0		1
Taper Length (ft)	25			25			25			25		
Right Turn on Red			Yes			Yes			Yes			Yes
Link Speed (mph)		25			25			25			35	
Link Distance (ft)		329			279			987			562	
Travel Time (s)		9.0			7.6			26.9			10.9	
Turn Type	Perm	NA		Perm	NA		Perm	NA		pm+pt	NA	Perm
Protected Phases		4			8			2		1	6	
Permitted Phases	4			8			2			6		6
Detector Phase	4	4		8	8		2	2		1	6	6
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0		15.0	15.0		4.0	15.0	15.0
Minimum Split (s)	10.0	10.0		10.0	10.0		21.0	21.0		10.0	21.0	21.0
Total Split (s)	19.0	19.0		19.0	19.0		21.0	21.0		10.0	31.0	31.0
Total Split (%)	38.0%	38.0%		38.0%	38.0%		42.0%	42.0%		20.0%	62.0%	62.0%
Maximum Green (s)	13.0	13.0		13.0	13.0		15.0	15.0		4.0	25.0	25.0
Yellow Time (s)	3.6	3.6		3.6	3.6		3.6	3.6		3.6	3.6	3.6
All-Red Time (s)	2.4	2.4		2.4	2.4		2.4	2.4		2.4	2.4	2.4
Lost Time Adjust (s)		0.0			0.0			0.0			0.0	0.0
Total Lost Time (s)		6.0			6.0			6.0			6.0	6.0
Lead/Lag							Lag	Lag		Lead		
Lead-Lag Optimize?							Yes	Yes		Yes		
Vehicle Extension (s)	1.5	1.5		1.5	1.5		2.0	2.0		1.0	2.0	2.0
Recall Mode	None	None		None	None		Min	Min		None	Min	Min
Walk Time (s)	7.0	7.0		7.0	7.0		7.0	7.0			7.0	7.0
Flash Dont Walk (s)	12.0	12.0		12.0	12.0		12.0	12.0			12.0	12.0
Pedestrian Calls (#/hr)	0	0		0	0		5	5			20	20

Intersection Summary	
Area Type:	Other
Cycle Length: 50	
Actuated Cycle Length: 42.4	
Natural Cycle: 50	
Control Type: Actuated-Uncoordinated	

Splits and Phases: 8: College & Edgewood/Strode Cir



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	222	283	72	263	0	390	2	186	2	0	1
Future Volume (vph)	1	222	283	72	263	0	390	2	186	2	0	1
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width (ft)	12	12	12	12	12	12	12	12	12	12	12	12
Storage Length (ft)	0		0	225		0	0		190	0		0
Storage Lanes	0		0	2		0	1		1	0		0
Taper Length (ft)	25			25			25			25		
Right Turn on Red			Yes			Yes			Yes			Yes
Link Speed (mph)		25			25			35			15	
Link Distance (ft)		432			659			734			143	
Travel Time (s)		11.8			18.0			14.3			6.5	
Turn Type	Perm	NA		Prot	NA		Perm	NA	Perm	Perm	NA	
Protected Phases		2		1	6			8			4	
Permitted Phases	2						8		8	4		
Detector Phase	2	2		1	6		8	8	8	4	4	
Switch Phase												
Minimum Initial (s)	12.0	12.0		3.0	30.0		4.0	4.0	4.0	4.0	4.0	
Minimum Split (s)	18.0	18.0		9.0	36.0		10.0	10.0	10.0	10.0	10.0	
Total Split (s)	28.0	28.0		10.0	38.0		25.0	25.0	25.0	25.0	25.0	
Total Split (%)	44.4%	44.4%		15.9%	60.3%		39.7%	39.7%	39.7%	39.7%	39.7%	
Maximum Green (s)	22.1	22.1		4.1	32.1		19.1	19.1	19.1	19.1	19.1	
Yellow Time (s)	3.6	3.6		3.6	3.6		3.6	3.6	3.6	3.6	3.6	
All-Red Time (s)	2.3	2.3		2.3	2.3		2.3	2.3	2.3	2.3	2.3	
Lost Time Adjust (s)		0.0		0.0	0.0		0.0	0.0	0.0		0.0	
Total Lost Time (s)		5.9		5.9	5.9		5.9	5.9	5.9		5.9	
Lead/Lag	Lead	Lead		Lag								
Lead-Lag Optimize?	Yes	Yes		Yes								
Vehicle Extension (s)	2.0	2.0		3.0	2.0		2.0	2.0	2.0	3.0	3.0	
Recall Mode	C-Min	C-Min		None	Min		None	None	None	None	None	
Walk Time (s)	7.0	7.0					7.0	7.0	7.0			
Flash Dont Walk (s)	29.0	29.0					17.0	17.0	17.0			
Pedestrian Calls (#/hr)	5	5					0	0	0			

Intersection Summary

Area Type: Other

Cycle Length: 63

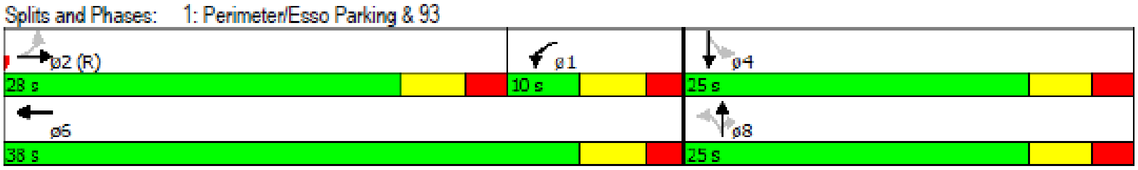
Actuated Cycle Length: 63

Offset: 28 (44%), Referenced to phase 2:EBTL, Start of Green

Natural Cycle: 55

Control Type: Actuated-Coordinated

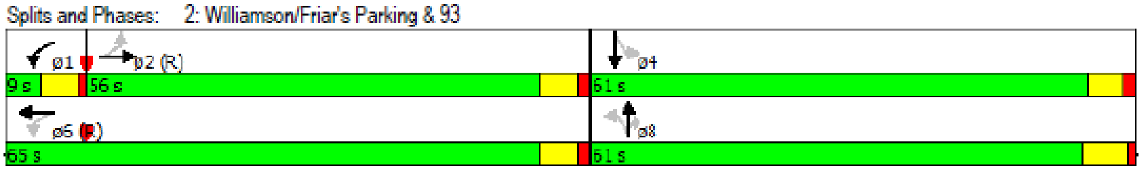
Splits and Phases: 1: Perimeter/Esso Parking & 93



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	342	93	173	232	2	135	0	370	3	0	0
Future Volume (vph)	1	342	93	173	232	2	135	0	370	3	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	0		100	0		0
Storage Lanes	0		0	0		0	0		1	0		0
Taper Length (ft)	25			25			25			25		
Right Turn on Red			Yes			Yes			Yes			Yes
Link Speed (mph)		25			25			25			15	
Link Distance (ft)		326			649			749			105	
Travel Time (s)		8.9			17.7			20.4			4.8	
Turn Type	Perm	NA		pm+pt	NA		Perm	NA	Perm	Perm	NA	
Protected Phases		2		1	6			8			4	
Permitted Phases	2			6			8		8	4		
Detector Phase	2	2		1	6		8	8	8	4	4	
Switch Phase												
Minimum Initial (s)	30.0	30.0		4.0	30.0		10.0	10.0	10.0	8.0	8.0	
Minimum Split (s)	35.5	35.5		9.0	35.5		16.0	16.0	16.0	13.5	13.5	
Total Split (s)	56.0	56.0		9.0	65.0		61.0	61.0	61.0	61.0	61.0	
Total Split (%)	44.4%	44.4%		7.1%	51.6%		48.4%	48.4%	48.4%	48.4%	48.4%	
Maximum Green (s)	50.5	50.5		4.0	59.5		55.0	55.0	55.0	55.5	55.5	
Yellow Time (s)	4.0	4.0		4.0	4.0		5.0	5.0	5.0	4.0	4.0	
All-Red Time (s)	1.5	1.5		1.0	1.5		1.0	1.0	1.0	1.5	1.5	
Lost Time Adjust (s)		0.0			0.0			0.0	0.0		0.0	
Total Lost Time (s)		5.5			5.5			6.0	6.0		5.5	
Lead/Lag	Lag	Lag		Lead								
Lead-Lag Optimize?	Yes	Yes		Yes								
Vehicle Extension (s)	4.0	4.0		3.0	4.0		3.0	3.0	3.0	4.0	4.0	
Minimum Gap (s)	4.0	4.0		3.0	4.0		3.0	3.0	3.0	4.0	4.0	
Time Before Reduce (s)	0.0	0.0		0.0	0.0		10.0	10.0	10.0	0.0	0.0	
Time To Reduce (s)	0.0	0.0		0.0	0.0		10.0	10.0	10.0	0.0	0.0	
Recall Mode	C-Min	C-Min		None	C-Min		None	None	None	None	None	
Walk Time (s)	7.0	7.0			7.0		7.0	7.0	7.0			
Flash Dont Walk (s)	20.0	20.0			20.0		20.0	20.0	20.0			
Pedestrian Calls (#/hr)	5	5			0		5	5	5			

Intersection Summary	
Area Type:	Other
Cycle Length: 126	
Actuated Cycle Length: 126	
Offset: 25 (20%), Referenced to phase 2:EBTL and 6:WBTL, Start of Green	
Natural Cycle: 65	
Control Type: Actuated-Coordinated	

Splits and Phases: 2: Williamson/Friar's Parking & 93



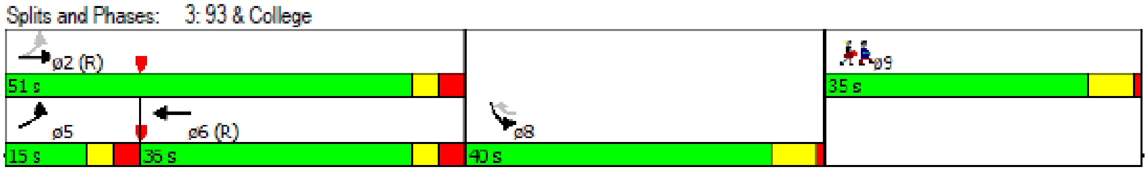
Lanes, Volumes, Timings
3: 93 & College

6/9/2015

Lane Group	EBL	EBT	WBT	WBR	SBL	SBR	ø9
Lane Configurations							
Traffic Volume (vph)	240	530	332	347	284	120	
Future Volume (vph)	240	530	332	347	284	120	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	
Storage Length (ft)	0			225	0	150	
Storage Lanes	1			1	2	1	
Taper Length (ft)	25				25		
Right Turn on Red				No		No	
Link Speed (mph)		25	25		25		
Link Distance (ft)		1228	295		485		
Travel Time (s)		33.5	8.0		13.2		
Turn Type	pm+pt	NA	NA	custom	Prot		
Protected Phases	5	2	6		8		9
Permitted Phases	2			8			
Detector Phase	5	2	6	8	8		
Switch Phase							
Minimum Initial (s)	6.0	30.0	30.0	10.0	10.0		27.0
Minimum Split (s)	12.0	36.0	36.0	16.0	16.0		35.0
Total Split (s)	15.0	51.0	36.0	40.0	40.0		35.0
Total Split (%)	11.9%	40.5%	28.6%	31.7%	31.7%		28%
Maximum Green (s)	9.0	45.0	30.0	34.0	34.0		29.0
Yellow Time (s)	3.0	3.0	3.0	5.0	5.0		5.0
All-Red Time (s)	3.0	3.0	3.0	1.0	1.0		1.0
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0		
Total Lost Time (s)	6.0	6.0	6.0	6.0	6.0		
Lead/Lag	Lead		Lag				
Lead-Lag Optimize?	Yes		Yes				
Vehicle Extension (s)	4.0	0.2	0.2	0.2	0.2		3.0
Minimum Gap (s)	4.0	0.2	0.2	3.0	3.0		3.0
Time Before Reduce (s)	0.0	0.0	0.0	10.0	10.0		0.0
Time To Reduce (s)	0.0	0.0	0.0	10.0	10.0		0.0
Recall Mode	None	C-Min	C-Min	None	None		None
Walk Time (s)							7.0
Flash Dont Walk (s)							20.0
Pedestrian Calls (#/hr)							100

Intersection Summary	
Area Type:	CBD
Cycle Length: 126	
Actuated Cycle Length: 126	
Offset: 45 (36%), Referenced to phase 2:EBTL and 6:WBT, Start of Green	
Natural Cycle: 120	
Control Type: Actuated-Coordinated	

Splits and Phases: 3: 93 & College

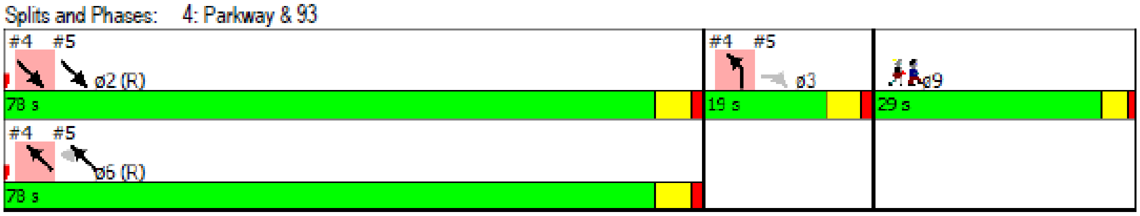


Lane Group	NBL	NBR	SET	SER	NWL	NWT	ø9
Lane Configurations							
Traffic Volume (vph)	78	0	655	121	0	627	
Future Volume (vph)	78	0	655	121	0	627	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	
Right Turn on Red		Yes		Yes			
Link Speed (mph)	15		25			25	
Link Distance (ft)	205		229			270	
Travel Time (s)	9.3		6.2			7.4	
Turn Type	Prot		NA			NA	
Protected Phases	3		2			6	9
Permitted Phases							
Detector Phase	3		2			6	
Switch Phase							
Minimum Initial (s)	3.0		35.0			35.0	25.0
Minimum Split (s)	8.5		40.5			40.5	29.0
Total Split (s)	19.0		78.0			78.0	29.0
Total Split (%)	15.1%		61.9%			61.9%	23%
Maximum Green (s)	13.5		72.5			72.5	25.0
Yellow Time (s)	4.0		4.0			4.0	3.0
All-Red Time (s)	1.5		1.5			1.5	1.0
Lost Time Adjust (s)	0.0		0.0			0.0	
Total Lost Time (s)	5.5		5.5			5.5	
Lead/Lag							
Lead-Lag Optimize?							
Vehicle Extension (s)	3.0		3.0			3.0	1.5
Minimum Gap (s)	3.0		3.0			3.0	3.0
Time Before Reduce (s)	10.0		0.0			10.0	0.0
Time To Reduce (s)	10.0		0.0			10.0	0.0
Recall Mode	None		C-Min			C-Min	None
Walk Time (s)							7.0
Flash Dont Walk (s)							11.0
Pedestrian Calls (#/hr)							100

Intersection Summary

Area Type: Other
Cycle Length: 126
Actuated Cycle Length: 126
Offset: 80 (63%), Referenced to phase 2:SET and 6:NWT, Start of Green
Natural Cycle: 80
Control Type: Actuated-Coordinated

Splits and Phases: 4: Parkway & 93

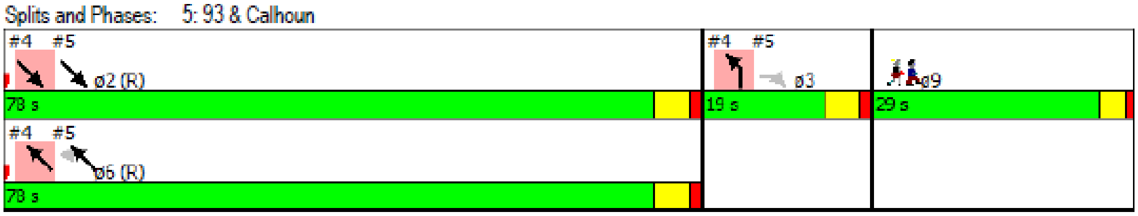


Lane Group	EBL	EBR	SET	SER	NWL	NWT	ø9
Lane Configurations							
Traffic Volume (vph)	0	71	655	0	140	627	
Future Volume (vph)	0	71	655	0	140	627	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	
Right Turn on Red		Yes		Yes			
Link Speed (mph)	15		25			25	
Link Distance (ft)	156		270			1508	
Travel Time (s)	7.1		7.4			41.1	
Turn Type		Perm	NA		Perm	NA	
Protected Phases			2			6	9
Permitted Phases		3			6		
Detector Phase		3	2		6	6	
Switch Phase							
Minimum Initial (s)		3.0	35.0		35.0	35.0	25.0
Minimum Split (s)		8.5	40.5		40.5	40.5	29.0
Total Split (s)		19.0	78.0		78.0	78.0	29.0
Total Split (%)		15.1%	61.9%		61.9%	61.9%	23%
Maximum Green (s)		13.5	72.5		72.5	72.5	25.0
Yellow Time (s)		4.0	4.0		4.0	4.0	3.0
All-Red Time (s)		1.5	1.5		1.5	1.5	1.0
Lost Time Adjust (s)		0.0	0.0			0.0	
Total Lost Time (s)		5.5	5.5			5.5	
Lead/Lag							
Lead-Lag Optimize?							
Vehicle Extension (s)		3.0	3.0		3.0	3.0	1.5
Minimum Gap (s)		3.0	3.0		3.0	3.0	3.0
Time Before Reduce (s)		10.0	0.0		10.0	10.0	0.0
Time To Reduce (s)		10.0	0.0		10.0	10.0	0.0
Recall Mode		None	C-Min		C-Min	C-Min	None
Walk Time (s)							7.0
Flash Dont Walk (s)							11.0
Pedestrian Calls (#/hr)							100

Intersection Summary

Area Type: Other
Cycle Length: 126
Actuated Cycle Length: 126
Offset: 80 (63%), Referenced to phase 2:SET and 6:NWT, Start of Green
Natural Cycle: 80
Control Type: Actuated-Coordinated

Splits and Phases: 5: 93 & Calhoun



Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Volume (vph)	662	153	180	538	250	225
Future Volume (vph)	662	153	180	538	250	225
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (ft)		0	150		0	75
Storage Lanes		0	1		1	1
Taper Length (ft)			25		25	
Right Turn on Red		Yes				Yes
Link Speed (mph)	25			40	15	
Link Distance (ft)	1508			733	570	
Travel Time (s)	41.1			12.5	25.9	
Turn Type	NA		pm+pt	NA	Prot	Perm
Protected Phases	2		1	6	8	
Permitted Phases			6			8
Detector Phase	2		1	6	8	8
Switch Phase						
Minimum Initial (s)	16.0		16.0	16.0	6.0	6.0
Minimum Split (s)	22.0		22.0	22.0	12.0	12.0
Total Split (s)	57.0		26.0	83.0	43.0	43.0
Total Split (%)	45.2%		20.6%	65.9%	34.1%	34.1%
Maximum Green (s)	51.1		20.1	77.1	37.0	37.0
Yellow Time (s)	3.6		3.6	3.6	5.0	5.0
All-Red Time (s)	2.3		2.3	2.3	1.0	1.0
Lost Time Adjust (s)	0.0		0.0	0.0	0.0	0.0
Total Lost Time (s)	5.9		5.9	5.9	6.0	6.0
Lead/Lag	Lag		Lead			
Lead-Lag Optimize?	Yes		Yes			
Vehicle Extension (s)	4.0		4.0	4.0	3.0	3.0
Minimum Gap (s)	4.0		4.0	4.0	3.0	3.0
Time Before Reduce (s)	0.0		0.0	0.0	10.0	10.0
Time To Reduce (s)	0.0		0.0	0.0	10.0	10.0
Recall Mode	C-Min		None	C-Min	None	None
Walk Time (s)	7.0				7.0	7.0
Flash Dont Walk (s)	15.0				20.0	20.0
Pedestrian Calls (#/hr)	5				0	0

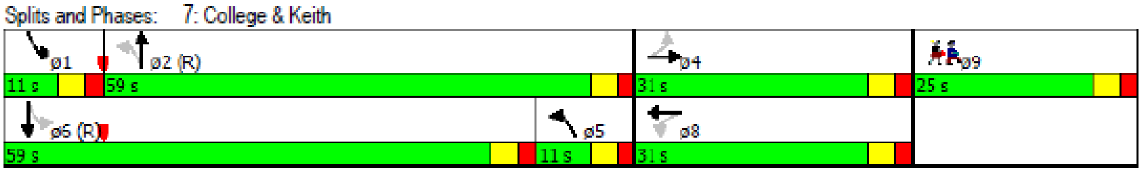
Intersection Summary
Area Type: Other
Cycle Length: 126
Actuated Cycle Length: 126
Offset: 1 (1%), Referenced to phase 2:EBT and 6:WBTL, Start of Green
Natural Cycle: 65
Control Type: Actuated-Coordinated

Splits and Phases: 6: Cherry & 93

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	59	5	70	60	6	94	43	409	35	53	327	29
Future Volume (vph)	59	5	70	60	6	94	43	409	35	53	327	29
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	50		0	50		0
Storage Lanes	0		0	0		0	1		0	1		0
Taper Length (ft)	25			25			25			25		
Right Turn on Red			Yes			Yes			Yes			Yes
Link Speed (mph)		25			25			25			25	
Link Distance (ft)		216			299			238			987	
Travel Time (s)		5.9			8.2			6.5			26.9	
Turn Type	Perm	NA		Perm	NA		pm+pt	NA		pm+pt	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8			2			6		
Detector Phase	4	4		8	8		5	2		1	6	
Switch Phase												
Minimum Initial (s)	20.0	20.0		20.0	20.0		6.0	43.0		6.0	43.0	
Minimum Split (s)	25.0	25.0		25.0	25.0		11.0	48.0		11.0	48.0	
Total Split (s)	31.0	31.0		31.0	31.0		11.0	59.0		11.0	59.0	
Total Split (%)	24.6%	24.6%		24.6%	24.6%		8.7%	46.8%		8.7%	46.8%	
Maximum Green (s)	26.0	26.0		26.0	26.0		6.0	54.0		6.0	54.0	
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
All-Red Time (s)	2.0	2.0		2.0	2.0		2.0	2.0		2.0	2.0	
Lost Time Adjust (s)		0.0			0.0		0.0	0.0		0.0	0.0	
Total Lost Time (s)		5.0			5.0		5.0	5.0		5.0	5.0	
Lead/Lag							Lag	Lag		Lead	Lead	
Lead-Lag Optimize?							Yes	Yes		Yes	Yes	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Recall Mode	None	None		None	None		None	C-Min		None	C-Min	
Walk Time (s)												
Flash Dont Walk (s)												
Pedestrian Calls (#/hr)												

Intersection Summary
Area Type: CBD
Cycle Length: 126
Actuated Cycle Length: 126
Offset: 86 (68%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green
Natural Cycle: 110
Control Type: Actuated-Coordinated

Splits and Phases: 7: College & Keith



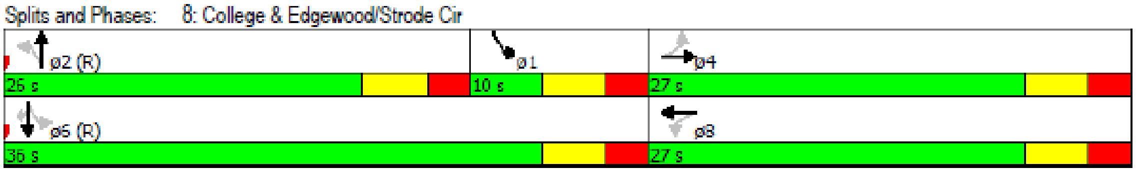
Lane Group	ø9
Lane Configurations	
Traffic Volume (vph)	
Future Volume (vph)	
Ideal Flow (vphpl)	
Storage Length (ft)	
Storage Lanes	
Taper Length (ft)	
Right Turn on Red	
Link Speed (mph)	
Link Distance (ft)	
Travel Time (s)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	20.0
Minimum Split (s)	25.0
Total Split (s)	25.0
Total Split (%)	20%
Maximum Green (s)	20.0
Yellow Time (s)	3.0
All-Red Time (s)	2.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Vehicle Extension (s)	3.0
Recall Mode	None
Walk Time (s)	7.0
Flash Dont Walk (s)	13.0
Pedestrian Calls (#/hr)	100

Intersection Summary

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	184	4	12	10	6	94	3	327	53	28	371	29
Future Volume (vph)	184	4	12	10	6	94	3	327	53	28	371	29
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	0		250	0		0
Storage Lanes	0		0	0		0	0		1	0		1
Taper Length (ft)	25			25			25			25		
Right Turn on Red			Yes			Yes			Yes			Yes
Link Speed (mph)		25			25			25			35	
Link Distance (ft)		329			279			987			562	
Travel Time (s)		9.0			7.6			26.9			10.9	
Turn Type	Perm	NA		Perm	NA		Perm	NA		pm+pt	NA	Perm
Protected Phases		4			8			2		1	6	
Permitted Phases	4			8			2			6		6
Detector Phase	4	4		8	8		2	2		1	6	6
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0		15.0	15.0		4.0	15.0	15.0
Minimum Split (s)	10.0	10.0		10.0	10.0		21.0	21.0		10.0	21.0	21.0
Total Split (s)	27.0	27.0		27.0	27.0		26.0	26.0		10.0	36.0	36.0
Total Split (%)	42.9%	42.9%		42.9%	42.9%		41.3%	41.3%		15.9%	57.1%	57.1%
Maximum Green (s)	21.0	21.0		21.0	21.0		20.0	20.0		4.0	30.0	30.0
Yellow Time (s)	3.6	3.6		3.6	3.6		3.6	3.6		3.6	3.6	3.6
All-Red Time (s)	2.4	2.4		2.4	2.4		2.4	2.4		2.4	2.4	2.4
Lost Time Adjust (s)		0.0			0.0			0.0			0.0	0.0
Total Lost Time (s)		6.0			6.0			6.0			6.0	6.0
Lead/Lag							Lead	Lead		Lag		
Lead-Lag Optimize?							Yes	Yes		Yes		
Vehicle Extension (s)	1.5	1.5		1.5	1.5		2.0	2.0		1.0	2.0	2.0
Recall Mode	None	None		None	None		C-Min	C-Min		None	C-Min	C-Min
Walk Time (s)	7.0	7.0		7.0	7.0		7.0	7.0			7.0	7.0
Flash Dont Walk (s)	12.0	12.0		12.0	12.0		12.0	12.0			12.0	12.0
Pedestrian Calls (#/hr)	0	0		0	0		5	5			20	20

Intersection Summary	
Area Type:	Other
Cycle Length: 63	
Actuated Cycle Length: 63	
Offset: 5 (8%), Referenced to phase 2:NBTL and 6:SBTL, Start of Green	
Natural Cycle: 50	
Control Type: Actuated-Coordinated	

Splits and Phases: 8: College & Edgewood/Strode Cir



Appendix E

Connected Vehicle Network Screenshots and RBC Timing

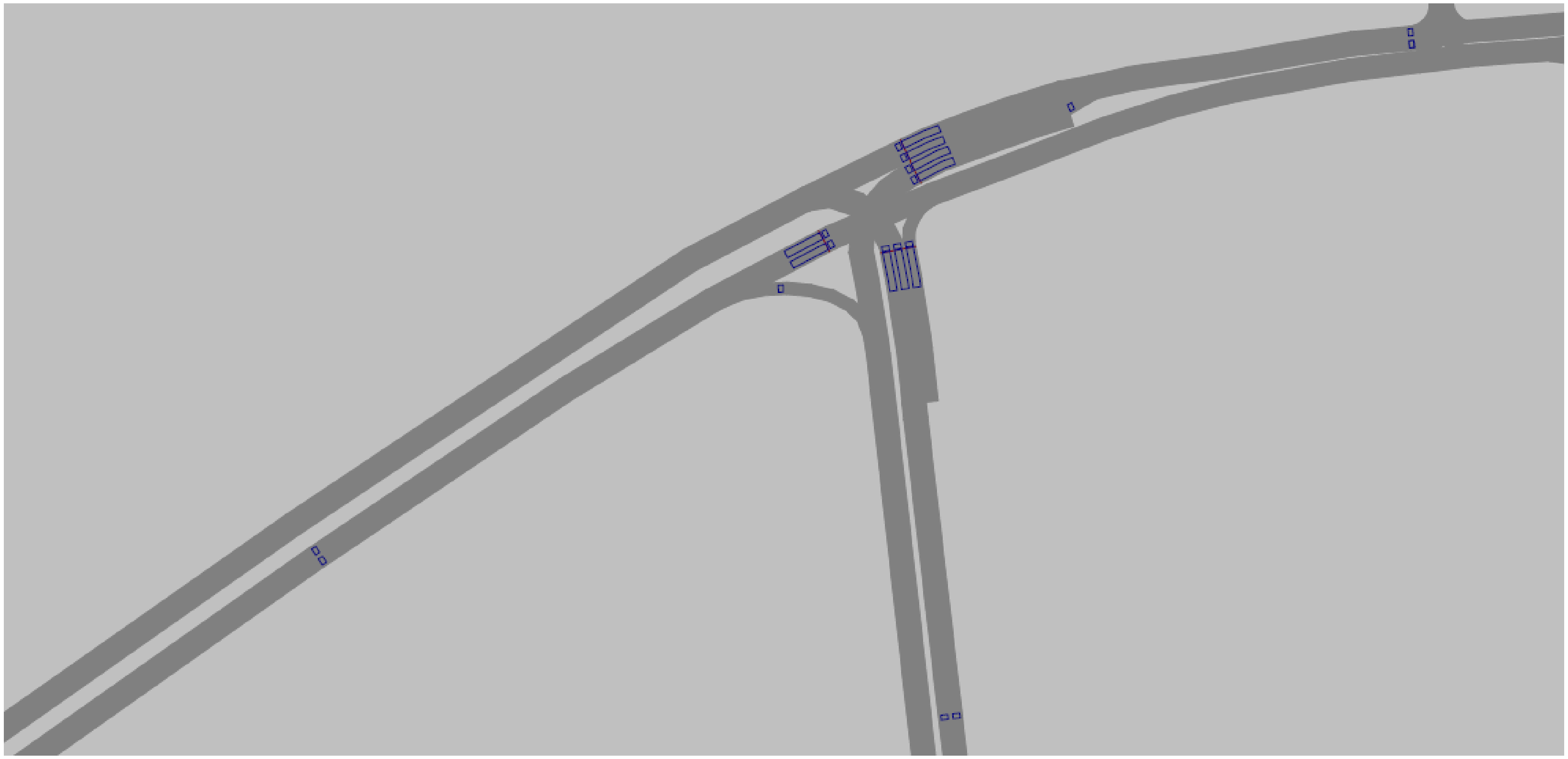


Figure D-1: US 93 @ Perimeter Rd. with CV Detectors

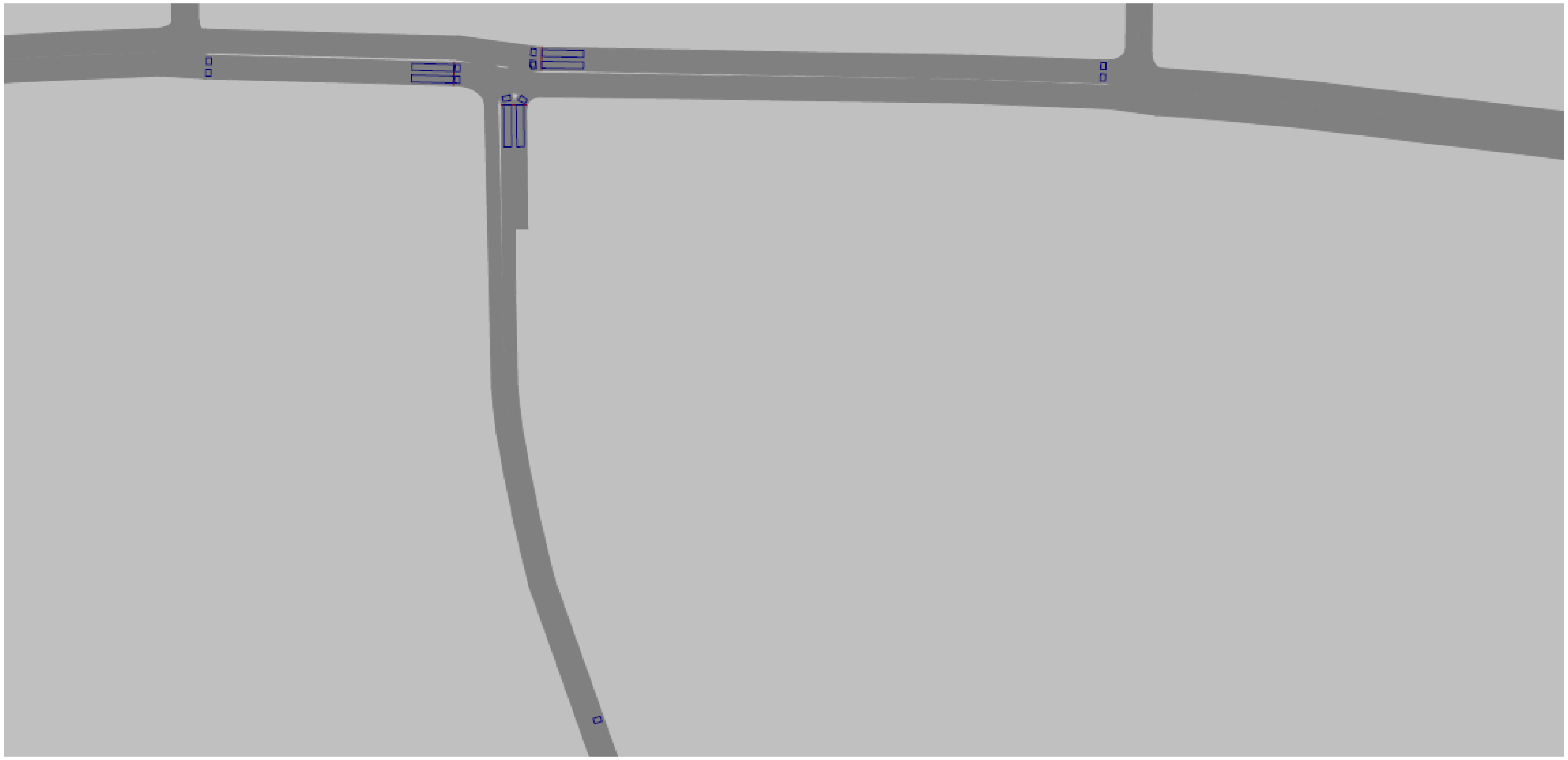


Figure D-2: US 93 @ Williamson Rd. with CV Detectors

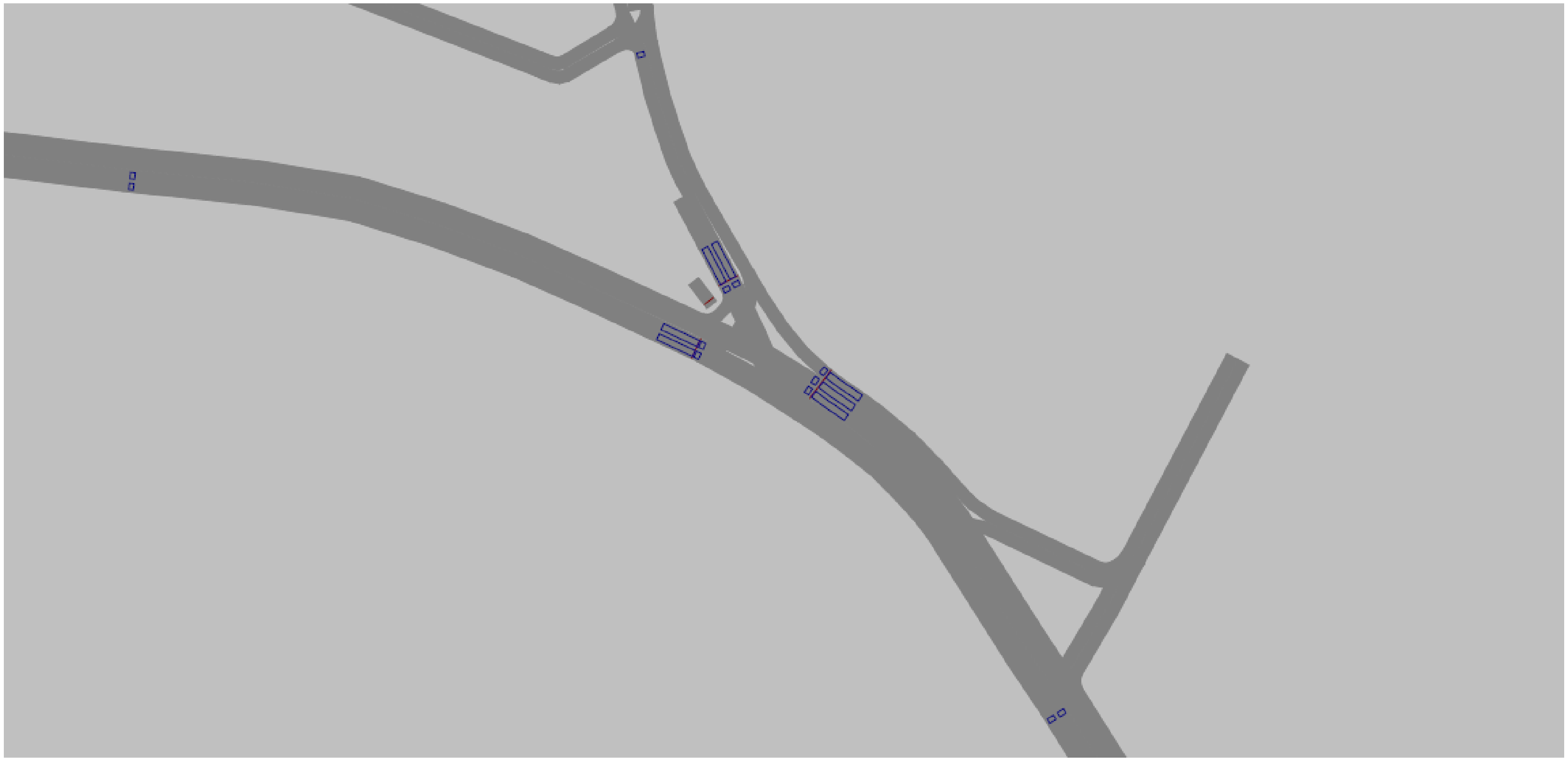


Figure D-3: US 93 @ College Ave. with CV Detectors

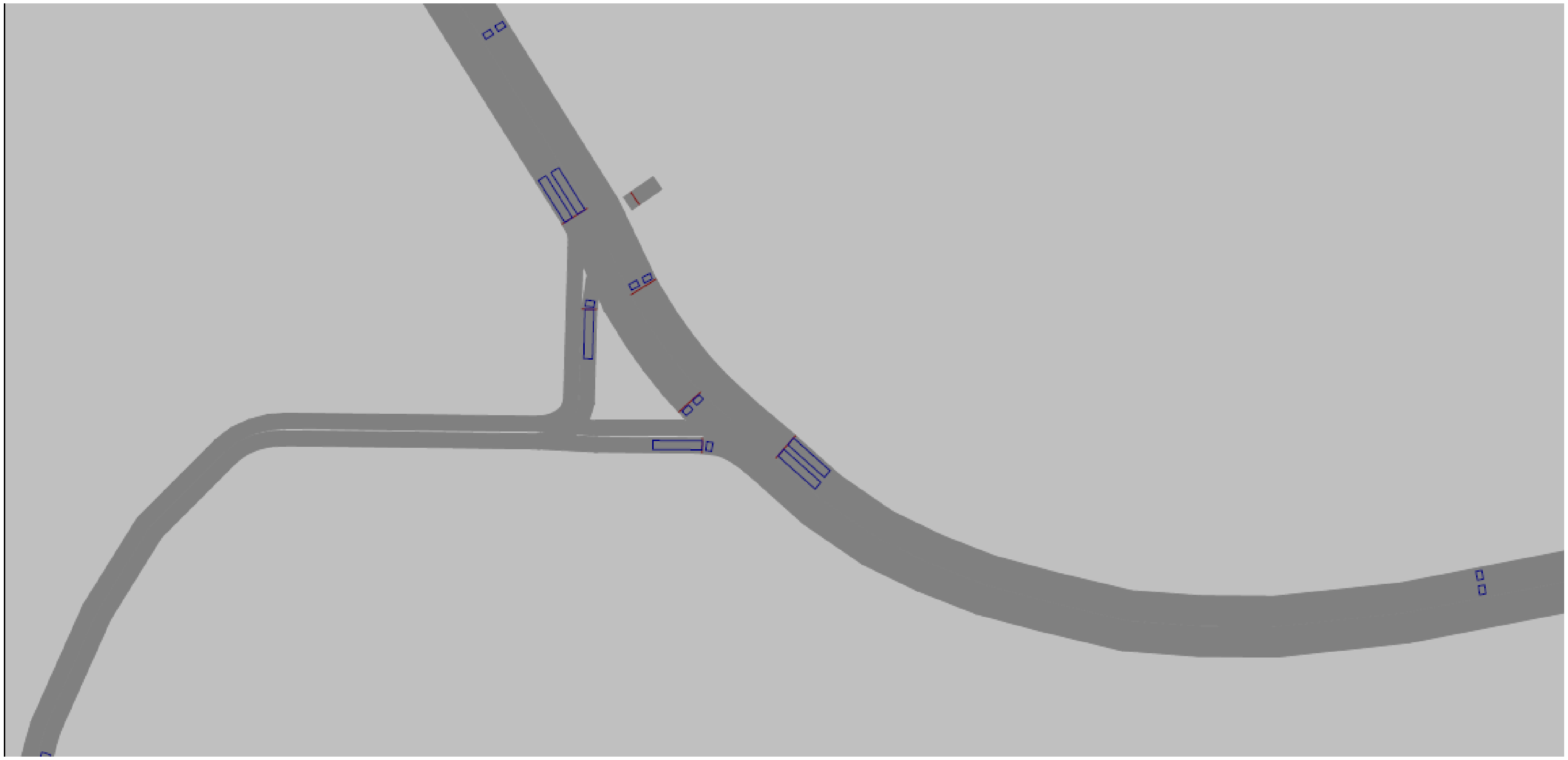


Figure D-4: US 93 @ Parkway Dr/Calhoun Dr. with CV Detectors

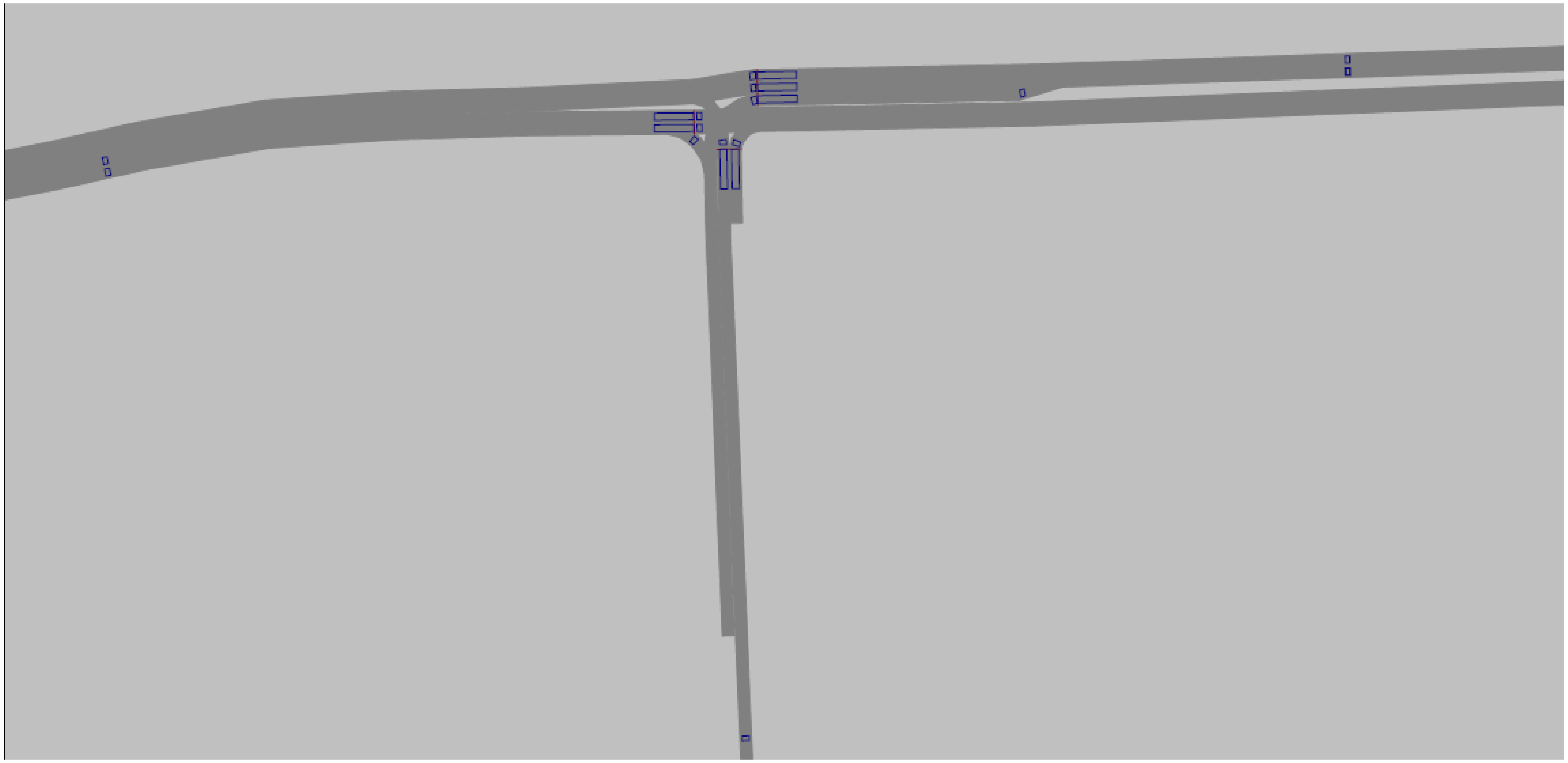


Figure D-5: US 93 @ Cherry Rd. with CV Detectors

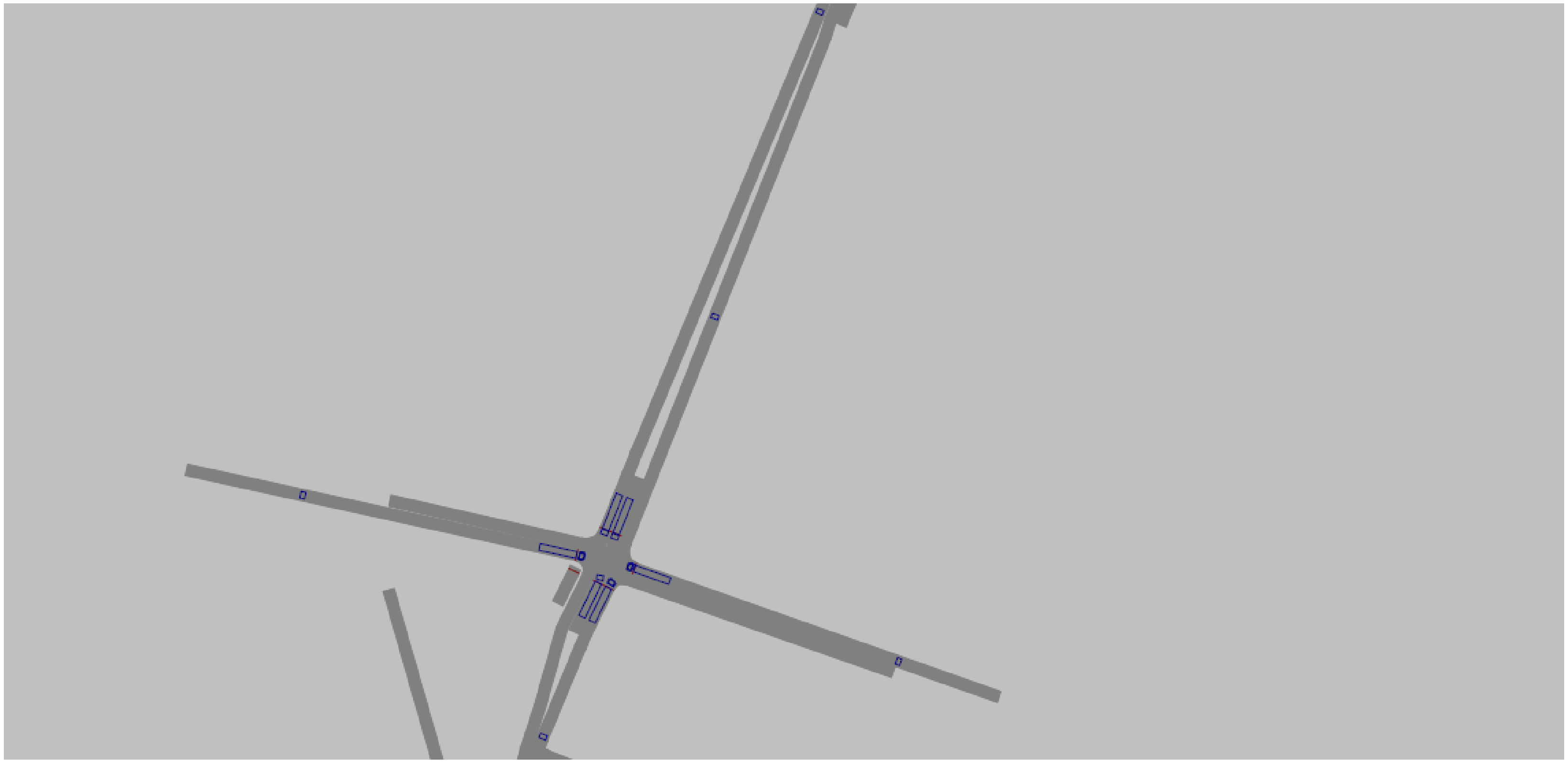


Figure D-6: College Ave. @ Keith St. with CV Detectors

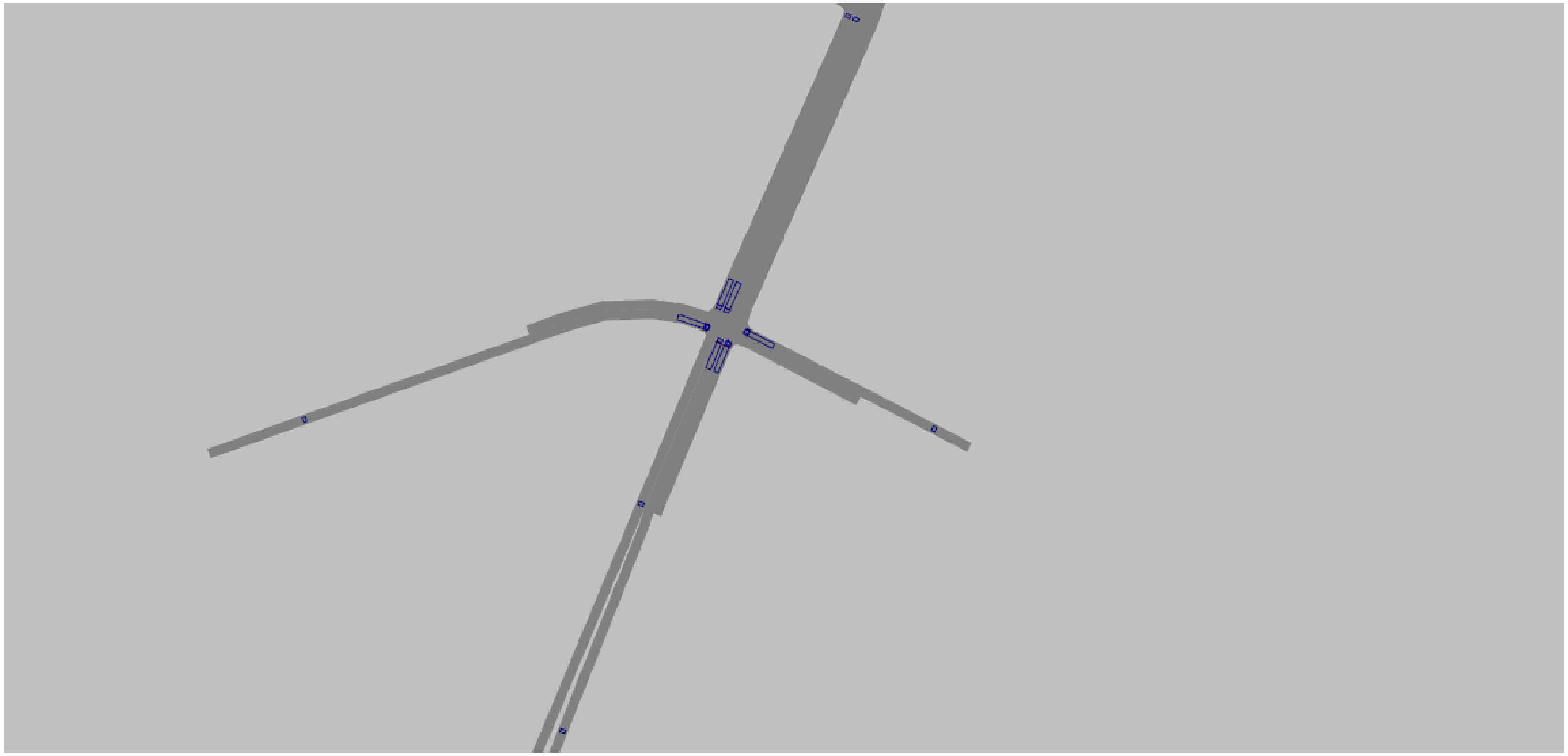


Figure D-7: College Ave. @ Edgewood Ave. with CV Detectors

Offset Reference : LeadGreen
Transition Mode : Best

Basic															
SG Number	1	2	6	8											
SG Name	WBL	EBT	WBT	NB											
Min Green	3	12	30	4											
Veh Extension	3	2	2	2											
Max 1	3	21	30	13											
Yellow	3.6	3.6	3.6	3.6											
Red Clearance	2.4	2.4	2.4	2.4											
Ped SG Number															
Walk															
Ped Clear (FDW)															
Start Up	☐	■	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Min Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ped Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soft Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
NSE Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dual Entry	☐	■	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Speed															

Sequence			
Ring 1	1	2	8
Ring 2	6		
Ring 3			
Ring 4			

Vehicle Detectors							
Detector Number	101	102	106	108			
Delay							
Extend							
Carry Over							
Queue Limit							
Detector Mode	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect
Added Initial Mode	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Call	1	2	6	8			
Yellow Lock							
Red Lock							
Extend SGs	1	2	6	8			
XSwitch SGs							
CallID							
Subtracted CallID							

Transit Priority	301	302	303	304	305	306	307	308
Use as Vissim SG	☐	☐	☐	☐	☐	☐	☐	☐
Parent SGs		2		0	0	0	0	0
No Call SGs		1						
Priority SGs		2						
Min Green								
Yellow								
Red Clearance								
Adv. Call Time		10						
Extension								
Call Mode	Non-Locked	Locked	Non-Locked	Recall	Recall	Recall	Recall	Recall
Priority								
Reservice Inh. Same								
Reservice Inh. All								

Free Running	301	302	303	304	305	306	307	308
Vehicle SG Omits		1						
Ped SG Omits								
Priority Mode	None	Early / Extend	None	None	None	None	None	None
Recovery Mode	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Extend Limit		11						

Transit Inputs	1	2	3	4	5	6
Call						
Call Transit SGs		302				
Checkout Detectors						
Delay Time						
Extend Time						
Travel Time		10				
Travel Time Slack		3				
Adjust Step						
Adjust Max						
Calling Pt. Detector	☐	☐	☐	☐	☐	☐
Lateness	0	0	0	0	0	0
Check Out Limit						
Check Out Mode	Normal	Normal	Normal	Normal	Normal	Normal
Detector Type	Checkin / Checkout	Checkin / Checkout	Checkin / Checkout	Checkin / Checkout	Checkin / Checkout	Checkin / Checl
Presence						
Check In	311	312	313	314	315	316
Check Out	321	322	323	324	325	326

Figure D-8: VISSIM Timing Inputs for US 93 @ Perimeter Rd. with CV Detectors

Offset Reference :	LeadGreen
Transition Mode :	Best

Basic															
SG Number	1	2	6	8											
SG Name	WBL	EBT	WBT	NB											
Min Green	4	30	30	10											
Veh Extension	3	4	4	3											
Max 1	4	30	39	14											
Yellow	4	4	4	5											
Red Clearance	1	1.5	1.5	1											
Ped SG Number															
Walk															
Ped Clear (FDW)															
Start Up	☐	■	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Min Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ped Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soft Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
NSE Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dual Entry	☐	■	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Speed															

Sequence			
Ring 1	1	2	8
Ring 2	6		
Ring 3			
Ring 4			

Vehicle Detectors							
Detector Number	101	102	106	108			
Delay							
Extend							
Carry Over							
Queue Limit							
Detector Mode	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect
Added Initial Mode	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Call	1	2	6	8			
Yellow Lock							
Red Lock							
Extend SGs	1	2	6	8			
XSwitch SGs							
CallID							
Subtracted CallID							

Transit Priority	301	302	303	304	305	306	307	308
Use as Vissim SG	☐	☐	☐	☐	☐	☐	☐	☐
Parent SGs		2						
No Call SGs		1						
Priority SGs		2						
Min Green								
Yellow								
Red Clearance								
Adv. Call Time								
Extension								
Call Mode	Non-Locked	Non-Locked	Non-Locked	Non-Locked	Non-Locked	Non-Locked	Non-Locked	Non-Locked
Priority								
Reservice Inh. Same								
Reservice Inh. All								

Free Running	301	302	303	304	305	306	307	308
Vehicle SG Omits		1						
Ped SG Omits								
Priority Mode	None	Early / Extend	None	None	None	None	None	None
Recovery Mode	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Extend Limit		20						

Transit Inputs	1	2	3	4	5	6	7
Call							
Call Transit SGs		302					
Checkout Detectors							
Delay Time							
Extend Time							
Travel Time		14					
Travel Time Slack		3					
Adjust Step							
Adjust Max							
Calling Pt. Detector	☐	☐	☐	☐	☐	☐	☐
Lateness	0	0	0	0	0	0	0
Check Out Limit							
Check Out Mode	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Detector Type	Checkin / Checkout	Checkin / Checkout	Checkin / Checkout	Checkin / Checkout	Presence	Presence	Presence
Presence					305	306	307
Check In	311	312	313	314			
Check Out	321	322	323	324			

Figure D-9: VISSIM Timing Inputs for US 93 @ Willaimson Rd. with CV Detectors

Offset Reference : LeadGreen
Transition Mode : Best

Basic															
SG Number	2	5	6	8	9										
SG Name	EBT	EBL	WBT	SB	PED										
Min Green	30	6	30	10											
Veh Extension	3	3	3	4											
Max 1	43	7	30	30	27										
Yellow	3	3	3	5	3										
Red Clearance	3	3	3	1	1										
Ped SG Number															
Walk															
Ped Clear (FDW)															
Start Up	■	□	■	□	□	□	□	□	□	□	□	□	□	□	□
Min Recall	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Max Recall	□	□	□	□	■	□	□	□	□	□	□	□	□	□	□
Ped Recall	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Soft Recall	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
NSE Max Recall	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Dual Entry	■	□	■	□	□	□	□	□	□	□	□	□	□	□	□
Max Speed															

Sequence				
Ring 1		2	8	9
Ring 2	5	6		
Ring 3				
Ring 4				

Vehicle Detectors							
Detector Number	102	105	106	108			
Delay							
Extend							
Carry Over							
Queue Limit							
Detector Mode	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect
Added Initial Mode	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Call	2	5	6	8			
Yellow Lock							
Red Lock							
Extend SGs	2	5	6	8			
XSwitch SGs							
CallID							
Subtracted CallID							

Transit Priority	301	302	303	304	305	306	307	308
Use as Vissim SG	□	□	□	□	□	□	□	□
Parent SGs		2			5	6		
No Call SGs								
Priority SGs		2			5	6		
Min Green								
Yellow								
Red Clearance								
Adv. Call Time		10			5	10		
Extension								
Call Mode	Non-Locked	Non-Locked	Non-Locked	Non-Locked	Non-Locked	Non-Locked	Non-Locked	Non-Locked
Priority								
Reservice Inh. Same								
Reservice Inh. All								

Free Running	301	302	303	304	305	306	307	308
Vehicle SG Omits								
Ped SG Omits								
Priority Mode	None	Early / Extend	None	None	Early / Extend	Early / Extend	None	None
Recovery Mode	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Extend Limit	1	14	1	1	10	14	1	

Transit Inputs	1	2	3	4	5	6
Call		2			5	6
Call Transit SGs		302			305	306
Checkout Detectors						
Delay Time						
Extend Time						
Travel Time		15			15	15
Travel Time Slack		6			6	6
Adjust Step						
Adjust Max						
Calling Pt. Detector	□	□	□	□	□	□
Lateness	0	0	0	0	0	0
Check Out Limit						
Check Out Mode	Normal	Normal	Normal	Normal	Normal	Normal
Detector Type	Checkin / Checkout	Checkin / Checkout	Checkin / Checkout	Checkin / Checkout	Checkin / Checkout	Checkin / Ch
Presence						
Check In	311	312	313	314	315	316
Check Out	321	322	323	324	325	326

Figure D-10: VISSIM Timing Inputs for US 93 @ College Ave. with CV Detectors

Offset Reference : LeadGreen
Transition Mode : Best

Basic															
SG Number	2	3	6	9											
SG Name	EB	NB	WB	PED											
Min Green	35	3	35	25											
Veh Extension	3	3	3												
Max 1	35	5	35	25											
Yellow	4	4	4	3											
Red Clearance	1.5	1.5	1.5	1											
Ped SG Number															
Walk															
Ped Clear (FDW)															
Start Up	■	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Min Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Recall	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ped Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soft Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
NSE Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dual Entry	■	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Speed															

Sequence			
Ring 1	2	3	9
Ring 2	6		
Ring 3			
Ring 4			

Vehicle Detectors							
Detector Number	102	103	106				
Delay							
Extend							
Carry Over							
Queue Limit							
Detector Mode	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect
Added Initial Mode	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Call	2	3	6				
Yellow Lock							
Red Lock							
Extend SGs	2	3	6				
XSwitch SGs							
CallID							
Subtracted CallID							

Transit Priority	301	302	303	304	305	306	307	308
Use as Vissim SG	☐	☐	☐	☐	☐	☐	☐	☐
Parent SGs						6		
No Call SGs								
Priority SGs						6		
Min Green								
Yellow								
Red Clearance								
Adv. Call Time								
Extension								
Call Mode	Recall	Recall	Recall	Recall	Recall	Non-Locked	Non-Locked	Non-Locked
Priority								
Reservice Inh. Same								
Reservice Inh. All								

Free Running	301	302	303	304	305	306	307	308
Vehicle SG Omits								
Ped SG Omits								
Priority Mode	None	None	None	None	None	Early / Extend	None	None
Recovery Mode	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Extend Limit						16		

Transit Inputs	1	2	3	4	5	6
Call						6
Call Transit SGs						306
Checkout Detectors						
Delay Time						
Extend Time						
Travel Time						15
Travel Time Slack						8
Adjust Step						
Adjust Max						
Calling Pt. Detector	☐	☐	☐	☐	☐	☐
Lateness	0	0	0	0	0	0
Check Out Limit						
Check Out Mode	Normal	Normal	Normal	Normal	Normal	Normal
Detector Type	Checkin / Checkout	Checkin / Checkout	Checkin / Checkout	Checkin / Checkout	Checkin / Checkout	Checkin / Che
Presence						
Check In	311	312	313	314	315	316
Check Out	321	322	323	324	325	326

Figure D-11: VISSIM Timing Inputs for US 93 @ Pkwy Dr/Calhoun Dr. with CV Det.

Offset Reference :	LeadGreen
Transition Mode :	Best

Basic															
SG Number	1	2	6	8											
SG Name	WBL	EBT	WBT	SB											
Min Green	16	16	16	6											
Veh Extension	2	4	4	4											
Max 1	16	19	41	12											
Yellow	3.6	3.6	3.6	3.6											
Red Clearance	2.4	2.4	2.4	2.4											
Ped SG Number															
Walk															
Ped Clear (FDW)															
Start Up	☐	■	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Min Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ped Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soft Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
NSE Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dual Entry	☐	■	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Speed															

Sequence			
Ring 1	1	2	8
Ring 2		6	
Ring 3			
Ring 4			

Vehicle Detectors							
Detector Number	101	102	106	108			
Delay							
Extend							
Carry Over							
Queue Limit							
Detector Mode	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect
Added Initial Mode	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Call	1	2	6	8			
Yellow Lock							
Red Lock							
Extend SGs	1	2	6	8			
XSwitch SGs							
CallID							
Subtracted CallID							

Transit Priority	301	302	303	304	305	306	307	308
Use as Vissim SG	☐	☐	☐	☐	☐	☐	☐	☐
Parent SGs						6		
No Call SGs								
Priority SGs						6		
Min Green								
Yellow								
Red Clearance								
Adv. Call Time								
Extension								
Call Mode	Non-Locked	Non-Locked	Non-Locked	Non-Locked	Non-Locked	Non-Locked	Non-Locked	Non-Locked
Priority								
Reservice Inh. Same								
Reservice Inh. All								

Free Running	301	302	303	304	305	306	307	308
Vehicle SG Omits								
Ped SG Omits								
Priority Mode	None	None	None	None	None	Early / Extend	None	None
Recovery Mode	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Extend Limit						13	1	

Transit Inputs	1	2	3	4	5	6
Call	0					6
Call Transit SGs						306
Checkout Detectors						
Delay Time						
Extend Time						
Travel Time						10
Travel Time Slack						2
Adjust Step						
Adjust Max						
Calling Pt. Detector	☐	☐	☐	☐	☐	☐
Lateness	0	0	0	0	0	0
Check Out Limit						
Check Out Mode	Normal	Normal	Normal	Normal	Normal	Normal
Detector Type	Checkin / Checkout	Checkin / Checkout	Checkin / Checkout	Checkin / Checkout	Checkin / Checkout	Checkin / Che
Presence						
Check In	311	312	313	314	315	316
Check Out	321	322	323	324	325	326

Figure D-12: VISSIM Timing Inputs for US 93 @ Cherry Rd. with CV Detectors

Offset Reference :	LeadGreen
Transition Mode :	Best

Basic															
SG Number	1	2	4	5	6	8	9								
SG Name	NBL	SB	EB	SBL	NB	WB	PED								
Min Green	3	22	10	3	22	10	20								
Veh Extension	3	3	3	3	3	3									
Max 1	6	44	20	6	44	20	20								
Yellow	3	3	3	3	3	3	3								
Red Clearance	2	2	2	2	2	2	2								
Ped SG Number															
Walk															
Ped Clear (FDW)															
Start Up	☐	■	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐
Min Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Recall	☐	☐	■	☐	☐	☐	■	☐	☐	☐	☐	☐	☐	☐	☐
Ped Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soft Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
NSE Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dual Entry	☐	■	■	☐	■	☐	■	☐	☐	☐	☐	☐	☐	☐	☐
Max Speed															

Sequence				
Ring 1	1	2	4	9
Ring 2	5	6	8	
Ring 3				
Ring 4				

Vehicle Detectors								
Detector Number	101	102	104	105	106	108		
Delay								
Extend								
Carry Over								
Queue Limit								
Detector Mode	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	I
Added Initial Mode	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	I
Call	1	2	4	5	6	8		
Yellow Lock								
Red Lock								
Extend SGs	1	2	4	5	6	8		
XSwitch SGs								
CallID								
Subtracted CallID								

Transit Priority	301	302	303	304	305	306	307	308
Use as Vissim SG	☐	☐	☐	☐	☐	☐	☐	☐
Parent SGs		2						
No Call SGs		1						
Priority SGs		2						
Min Green								
Yellow								
Red Clearance								
Adv. Call Time								
Extension								
Call Mode	Non-Locked	Non-Locked	Non-Locked	Non-Locked	Non-Locked	Non-Locked	Non-Locked	Non-Locked
Priority								
Reservice Inh. Same								
Reservice Inh. All								

Free Running	301	302	303	304	305	306	307	308
Vehicle SG Omits		1						
Ped SG Omits								
Priority Mode	None	Early / Extend	None	None	None	None	None	None
Recovery Mode	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Extend Limit		22						

Transit Inputs	1	2	3	4	5	6	7	8
Call		2						
Call Transit SGs		302						
Checkout Detectors								
Delay Time								
Extend Time								
Travel Time		5						
Travel Time Slack		2						
Adjust Step								
Adjust Max								
Calling Pt. Detector	☐	☐	☐	☐	☐	☐	☐	☐
Lateness	0	0	0	0	0	0	0	0
Check Out Limit								
Check Out Mode	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Detector Type	Checkin / Checkout	Checkin / Checkout	Presence	Presence	Presence	Presence	Presence	Presence
Presence			303	304	305	306	307	308
Check In	311	312						
Check Out	321	322						

Figure D-13: VISSIM Timing Inputs for College Ave. @ Keith St. with CV Detectors

Offset Reference : LeadGreen
Transition Mode : Best

Basic															
SG Number	1	2	4	6	8										
SG Name	SBL	NB	EB	NB	WB										
Min Green	4	15	4	15	4										
Veh Extension	1	2	1.5	2	1.5										
Max 1	4	15	13	25	13										
Yellow	3.6	3.6	3.6	3.6	3.6										
Red Clearance	2.4	2.4	2.4	2.4	2.4										
Ped SG Number															
Walk															
Ped Clear (FDW)															
Start Up	☐	■	☐	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Min Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ped Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Soft Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
NSE Max Recall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dual Entry	☐	■	■	■	■	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Max Speed															

Sequence			
Ring 1	1	2	4
Ring 2		6	8
Ring 3			
Ring 4			

Vehicle Detectors							
Detector Number	101	102	104	106	108		
Delay							
Extend							
Carry Over							
Queue Limit							
Detector Mode	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect	No Disconnect
Added Initial Mode	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Call	1	2	4	6	8		
Yellow Lock							
Red Lock							
Extend SGs	1	2	4	6	8		
XSwitch SGs							
CallID							
Subtracted CallID							

Transit Priority	301	302	303	304	305	306	307	308
Use as Vissim SG	☐	☐	☐	☐	☐	☐	☐	☐
Parent SGs		2						
No Call SGs		1						
Priority SGs		2						
Min Green								
Yellow								
Red Clearance								
Adv. Call Time								
Extension								
Call Mode	Non-Locked	Non-Locked	Non-Locked	Non-Locked	Non-Locked	Non-Locked	Non-Locked	Non-Locked
Priority								
Reservice Inh. Same								
Reservice Inh. All								

Free Running	301	302	303	304	305	306	307	308
Vehicle SG Omits		1						
Ped SG Omits								
Priority Mode	None	Early / Extend	None	None	None	None	None	None
Recovery Mode	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Extend Limit		10						

Transit Inputs	1	2	3	4	5	6
Call		2				
Call Transit SGs		302				
Checkout Detectors						
Delay Time						
Extend Time						
Travel Time		15				
Travel Time Slack		2				
Adjust Step						
Adjust Max						
Calling Pt. Detector	☐	☐	☐	☐	☐	☐
Lateness	0	0	0	0	0	0
Check Out Limit						
Check Out Mode	Normal	Normal	Normal	Normal	Normal	Normal
Detector Type	Checkin / Checkout	Checkin / Checkout	Checkin / Checkout	Checkin / Checkout	Checkin / Checkout	Checkin / Che
Presence						
Check In	311	312	313	314	315	316
Check Out	321	322	323	324	325	326

Figure D-14: VISSIM Timing Inputs for College Ave. @ Edgewood Ave. with CV Det.

Appendix F

Sample VISSIM Simulation Outputs

Sample 1: Network Delay for 4% CV Scenario, Seed 14

Network Performance

File: c:\gende\new\vissimnet - cv3.0\sat.inp
Comment:
Date: Monday, June 08, 2015 6:12:02 PM
VISSIM: 5.40-08 [38878]

Simulation time from 600.0 to 7800.0.

Parameter	;	Value;
Average delay time per vehicle [s], All Vehicle Types	;	54.324;
Average delay time per vehicle [s], Vehicle Class Car	;	54.434;
Average delay time per vehicle [s], Vehicle Class CV	;	52.614;

Sample 2: Node Data Collection for 8% CV Scenario, Seed 238

Node evaluation

File: c:\gende\new\vissimnet - cv3.0 - copy\sat.inp
Comment:
Date: Monday, June 08, 2015 7:38:15 PM
VISSIM: 5.40-08 [38878]

Node 1: 93/College
Node 2: Perimeter
Node 3: Williamson
Node 4: Calhoun
Node 5: Cherry
Node 6: Keith
Node 7: Edgewood

Node: Node Number
FromLink: Number of the link entering node
ToLink: Number of the link leaving node
veh(11): Number of Vehicles, Vehicle Class CV
Delay(All): Average delay per vehicle [s], All Vehicle Types
Delay(10): Average delay per vehicle [s], Vehicle Class Car
Delay(11): Average delay per vehicle [s], Vehicle Class CV
aveQueue: Average Queue Length [ft]

Node;	FromLink;	ToLink;	veh(11);	Delay(All);	Delay(10);	Delay(11);	aveQueue;
1;	7;	8;	31;	26.7;	26.6;	30.6;	75.9;
1;	7;	16;	26;	32.8;	31.9;	40.6;	75.9;
1;	48;	46;	25;	37.5;	37.8;	33.2;	54.5;
1;	48;	16;	30;	25.0;	25.4;	21.2;	54.5;
1;	50;	46;	11;	47.2;	46.4;	55.2;	95.5;
1;	50;	8;	29;	44.8;	44.2;	49.6;	95.5;
1;	0;	0;	152;	33.4;	33.2;	36.3;	75.3;
2;	1;	28;	15;	0.6;	0.5;	0.7;	0.0;
2;	1;	2;	20;	18.8;	19.2;	16.0;	12.8;
2;	27;	26;	31;	15.1;	15.0;	15.1;	17.5;
2;	27;	2;	20;	7.4;	7.5;	5.7;	17.5;
2;	31;	26;	22;	6.9;	7.0;	5.7;	4.5;
2;	29;	28;	9;	14.1;	13.7;	16.1;	4.2;
2;	0;	0;	117;	10.1;	10.1;	10.1;	9.4;
3;	43;	6;	27;	9.7;	9.7;	10.3;	0.8;
3;	43;	38;	7;	15.8;	16.0;	13.0;	14.3;
3;	44;	42;	17;	7.9;	8.0;	6.7;	6.3;

3;	44;	38;	20;	5.8;	5.8;	4.6;	6.3;
3;	5;	42;	8;	12.0;	12.0;	11.3;	17.4;
3;	5;	6;	33;	13.3;	13.1;	13.9;	17.4;
3;	0;	0;	112;	10.5;	10.4;	10.0;	10.4;
4;	64;	58;	7;	32.8;	33.8;	24.8;	14.2;
4;	65;	12;	1;	7.2;	7.0;	5.2;	0.0;
4;	10;	63;	6;	13.6;	13.0;	26.7;	27.5;
4;	10;	12;	56;	16.6;	16.6;	16.5;	35.5;
4;	60;	61;	16;	37.7;	38.1;	31.7;	53.3;
4;	60;	58;	49;	19.5;	19.2;	23.3;	53.3;
4;	0;	0;	135;	19.4;	19.2;	21.6;	30.6;
5;	14;	72;	6;	15.4;	15.2;	21.2;	12.0;
5;	69;	60;	43;	7.6;	7.5;	8.1;	10.1;
5;	71;	13;	17;	13.7;	13.7;	13.3;	12.4;
5;	71;	60;	23;	25.1;	25.6;	22.3;	37.4;
5;	12;	13;	47;	11.3;	11.2;	13.0;	18.6;
5;	12;	72;	12;	9.4;	8.8;	15.1;	6.4;
5;	0;	0;	148;	12.6;	12.5;	13.6;	16.1;
6;	86;	87;	1;	16.7;	16.5;	17.9;	5.6;
6;	86;	81;	6;	11.0;	11.3;	9.7;	5.6;
6;	86;	20;	7;	10.5;	10.2;	13.9;	2.1;
6;	88;	85;	0;	64.4;	64.4;	0.0;	16.9;
6;	88;	81;	5;	18.9;	18.1;	34.4;	6.3;
6;	88;	20;	7;	26.2;	24.9;	32.2;	16.9;
6;	82;	85;	3;	41.7;	43.7;	24.4;	129.4;
6;	82;	87;	7;	60.1;	61.8;	49.6;	164.8;
6;	82;	20;	38;	40.3;	40.1;	42.4;	164.8;
6;	83;	85;	3;	46.7;	48.1;	30.5;	78.3;
6;	83;	87;	0;	30.8;	30.8;	0.0;	57.5;
6;	83;	81;	27;	32.9;	32.7;	34.8;	78.3;
6;	0;	0;	104;	33.2;	33.0;	34.9;	60.5;
7;	96;	101;	16;	5.2;	5.4;	4.5;	10.6;
7;	96;	102;	3;	7.0;	6.6;	10.6;	10.6;
7;	96;	84;	28;	6.2;	6.1;	7.1;	10.6;
7;	99;	22;	2;	6.5;	7.2;	0.7;	0.2;
7;	99;	101;	1;	10.3;	8.8;	14.7;	1.3;
7;	99;	84;	0;	18.7;	18.7;	0.0;	1.3;
7;	100;	22;	12;	23.7;	24.1;	18.9;	23.8;
7;	100;	102;	0;	20.3;	20.3;	0.0;	23.8;
7;	100;	84;	2;	11.3;	11.6;	9.7;	6.9;
7;	21;	22;	51;	10.1;	10.2;	9.8;	16.3;
7;	21;	101;	0;	5.8;	5.8;	0.0;	16.3;
7;	21;	102;	1;	10.5;	10.9;	6.6;	6.4;
7;	0;	0;	116;	10.4;	10.5;	9.2;	10.7;

0;	0;	0;	884;	18.7;	18.6;	19.7;	31.6;
1;	7;	8;	49;	23.4;	23.4;	24.2;	71.2;
1;	7;	16;	23;	33.0;	32.4;	34.4;	71.2;
1;	48;	46;	27;	40.7;	39.8;	44.4;	63.4;
1;	48;	16;	35;	30.1;	29.9;	31.5;	63.4;
1;	50;	46;	11;	41.1;	42.2;	27.3;	78.1;
1;	50;	8;	19;	46.9;	46.7;	47.7;	78.1;
1;	0;	0;	164;	33.9;	33.8;	33.4;	70.9;
2;	1;	28;	29;	0.8;	0.8;	0.6;	0.1;
2;	1;	2;	18;	15.2;	15.0;	16.1;	10.8;
2;	27;	26;	30;	13.9;	13.9;	12.6;	14.8;
2;	27;	2;	20;	7.2;	7.1;	7.5;	14.8;
2;	31;	26;	36;	5.4;	5.3;	6.6;	4.7;
2;	29;	28;	15;	12.6;	12.6;	12.0;	4.1;
2;	0;	0;	148;	8.8;	8.8;	8.5;	8.2;
3;	43;	6;	38;	9.3;	9.3;	8.4;	1.8;
3;	43;	38;	15;	14.8;	14.8;	12.1;	15.2;
3;	44;	42;	10;	7.1;	7.0;	5.9;	5.4;
3;	44;	38;	30;	4.5;	4.9;	1.8;	5.4;
3;	5;	42;	7;	14.4;	13.2;	19.9;	18.0;
3;	5;	6;	34;	12.8;	12.8;	12.6;	18.0;
3;	0;	0;	134;	9.8;	9.8;	8.8;	10.6;
4;	64;	58;	12;	37.5;	35.9;	48.3;	18.9;
4;	65;	12;	7;	7.1;	7.1;	7.2;	0.0;
4;	10;	63;	10;	17.9;	18.6;	8.0;	52.6;
4;	10;	12;	51;	22.2;	22.1;	21.3;	62.0;
4;	60;	61;	11;	40.4;	40.4;	41.1;	55.5;
4;	60;	58;	46;	20.7;	20.5;	23.5;	55.5;
4;	0;	0;	137;	22.8;	22.6;	24.3;	40.7;
5;	14;	72;	7;	18.1;	17.9;	13.9;	14.0;
5;	69;	60;	40;	7.7;	7.6;	8.4;	11.1;
5;	71;	13;	15;	12.5;	12.2;	14.7;	9.6;
5;	71;	60;	16;	23.0;	23.5;	17.0;	30.6;
5;	12;	13;	50;	10.9;	10.7;	10.6;	20.7;
5;	12;	72;	7;	10.3;	10.0;	17.0;	9.8;
5;	0;	0;	135;	12.1;	12.1;	11.6;	16.0;
6;	86;	87;	1;	2.9;	0.5;	7.7;	7.7;
6;	86;	81;	2;	12.7;	13.1;	7.2;	7.7;
6;	86;	20;	8;	13.9;	13.7;	14.9;	3.8;
6;	88;	85;	0;	56.0;	56.0;	0.0;	16.7;
6;	88;	81;	8;	17.2;	18.3;	8.2;	4.7;
6;	88;	20;	2;	33.2;	34.6;	1.5;	16.7;
6;	82;	85;	3;	39.5;	39.3;	41.7;	199.2;
6;	82;	87;	2;	61.9;	60.1;	105.6;	235.2;

6;	82;	20;	36;	45.8;	46.6;	38.0;	235.2;
6;	83;	85;	6;	58.2;	57.4;	64.9;	106.1;
6;	83;	87;	4;	32.6;	30.0;	45.5;	84.9;
6;	83;	81;	24;	40.6;	40.7;	41.2;	106.1;
6;	0;	0;	96;	38.1;	38.4;	36.2;	85.3;
7;	96;	101;	9;	2.9;	3.2;	0.4;	8.6;
7;	96;	102;	4;	10.4;	9.5;	11.5;	8.6;
7;	96;	84;	32;	5.4;	5.5;	5.6;	8.6;
7;	99;	22;	1;	7.6;	7.1;	6.4;	0.3;
7;	99;	101;	0;	22.2;	0.0;	0.0;	2.0;
7;	99;	84;	0;	35.1;	35.1;	0.0;	2.0;
7;	100;	22;	10;	30.7;	30.4;	31.7;	31.5;
7;	100;	102;	0;	23.5;	23.5;	0.0;	31.5;
7;	100;	84;	1;	26.0;	30.0;	7.6;	12.0;
7;	21;	22;	45;	9.5;	9.2;	10.1;	17.1;
7;	21;	101;	0;	0.0;	0.0;	0.0;	17.1;
7;	21;	102;	0;	3.3;	3.3;	0.0;	6.3;
7;	0;	0;	102;	11.0;	10.9;	10.0;	12.2;
0;	0;	0;	916;	19.5;	19.4;	18.9;	37.9;

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