Data Analytics and Evaluation of the Gainesville Trapezium Connected Vehicle Signal Phasing and Timing (SPaT) Deployment Project

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16. Abstract The overall goal of this project was to evaluate the efficacy of dedicated short-range communications (DSRC) in improving efficiency and safety within a network of signalized intersections. In this report, we describe the data collection, processing, and analysis mechanisms for traffic state data collected from the Gainesville Trapezium, a set of high-volume arterials surrounding the University of Florida in the City of Gainesville. The Trapezium is instrumented with various sensing equipment, including high-resolution loop detectors, video cameras, DSRC roadside, and vehicles with on-board units. We describe the data collection and processing software architecture, consisting of edge computation, local servers, and cloud-based components that we use to deploy our applications. We conducted a baseline study on the state of traffic before the implementation of the DSRC system ("before" study). In the data collection phase of the project, we tested the performance of our data collection pipeline, with a focus on DSRC data, as well as collecting "after" data in order to determine the efficacy of the deployed DSRC system. We interviewed drivers of vehicles with on-board units to learn about their experience with the system. We also discuss the impact of COVID-19 pandemic-related closures on the state of traffic on the Trapezium, which occurred during the duration of this project.			
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Executive Summary

The I-STREET project is a collaboration among the Florida Department of Transportation (FDOT), the City of Gainesville (CoG), and University of Florida (UF). I-STREET “deploys and evaluates numerous advanced technologies, including connected and autonomous vehicles, smart devices, and sensors, [and] develops and applies novel applications to enhance mobility and safety” (University of Florida Transportation Institute website). The Gainesville signal phasing and timing (SPaT) Trapezium is a part of I-STREET formed by the four roads that bound the UF main campus. Approximately, 50 DSRC roadside units (RSUs) are installed at 27 Trapezium intersections in this project. The roadways and intersections along and within this "Trapezium" and bus routes serving this area constituted the fundamental real-world test bed for this study. Some of the signalized intersections of interest to this study have live multimodal video detection for pedestrians, bicycles, and vehicles. Some of the intersections are also equipped with fish-eye video detection with motion tracking and vehicle classification. Advanced traffic controllers (ATC) can provide signal-timing history at decisecond resolution.

The overall goal of this project was to evaluate the efficacy of dedicated short-range communications (DSRC) in improving efficiency and safety within a network of signalized intersections. In this report, we describe the data collection, processing, and analysis mechanisms for traffic state data collected from the Gainesville Trapezium, a set of high-volume arterials surrounding the University of Florida in the City of Gainesville. The Trapezium is instrumented with various sensing equipment, including high-resolution loop detectors, video cameras, DSRC roadside, and vehicles with on-board units. We describe the data collection and processing software architecture, consisting of edge computation, local servers, and cloud-based components that we use to deploy our applications. We conducted a baseline study on the state of traffic before the implementation of the DSRC system (“before” study). In the data collection phase of the project, we tested the performance of our data collection pipeline, with a focus on DSRC data, as well as collecting “after” data in order to determine the efficacy of the deployed DSRC system. We interviewed drivers of vehicles with on-board units to learn about their experience with the system. We also discuss the impact of COVID-19 pandemic-related closures on the state of traffic on the Trapezium, which occurred during the duration of this project.

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Chapter 1 – Introduction

Transportation systems are essential for daily human activities. In 2014, traffic congestion caused Americans in urban areas to purchase an extra 3.1 billion gallons of fuel and accounted for nearly $160 billion in congestion cost (Shrank et al., 2015). Traffic signals specifically contributed to up to 10 percent of all traffic delay, which aggregated to nearly 295 million vehicle-hours of delay on major roadways only (ITE, 1997). By some estimates, the percentage of the population that spends at least one hour on the road each day is as high as 40%. The use of dedicated short-range communication (DSRC) and connected vehicle technology has the potential to alleviate this congestion as well as to improve overall safety.

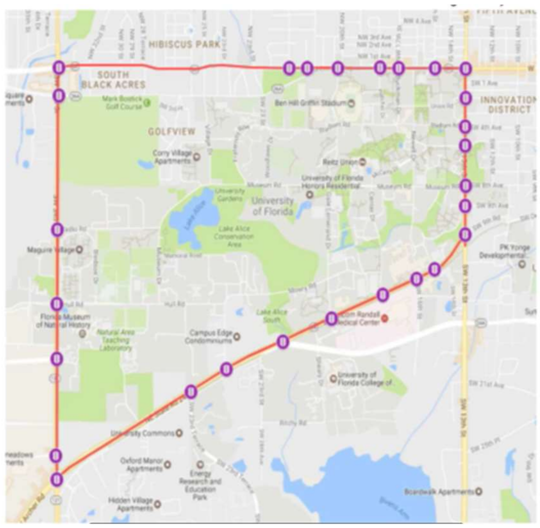

Figure 1-1. Gainesville SPaT Trapezium

Intelligent transportation systems allow interaction between road users and infrastructure. DSRC, which uses radio, Wi-Fi, or cellular technologies, can enable such interactions at signalized intersections. By using these effectively, the infrastructure system can provide information to the users about the status of the system as well as use them as probes to create a vignette of local and network level traffic patterns and usages.

The I-STREET project is a collaboration among the Florida Department of Transportation (FDOT), the City of Gainesville (CoG), and University of Florida (UF). I-STREET "deploys and evaluates numerous advanced technologies, including connected and autonomous vehicles, smart devices, and sensors, [and] develops and applies novel applications to enhance mobility and safety" (University of Florida Transportation Institute website). The Gainesville signal phasing and timing (SPaT) Trapezium is a part of I-STREET formed by the four roads that bound the UF main campus. Approximately, 50 DSRC roadside units (RSUs) are installed at 27 Trapezium intersections in this project. The roadways and intersections along and within this "Trapezium" and bus routes serving this area constituted the fundamental real-world test bed for this study. Some of the signalized intersections of interest to this study have live multimodal video detection for pedestrians, bicycles, and vehicles. Some of the intersections are also equipped with fish-eye video detection with motion tracking and vehicle classification. Advanced traffic controllers (ATC) can provide signal-timing history at decisecond resolution.

The overall goal of this project was to evaluate the efficacy of DSRC in improving efficiency and safety within a network of signalized intersections. Besides FDOT engineers, the research team worked closely with the selected vendor for deployment (Siemens Mobility, Inc.) and the CoG engineers to collect data required for performance evaluation in this project. Data from automated traffic signal performance measures (ATSPM) and from CV devices and other systems were stored in a cloud-based server. The collected data were analyzed to understand the trends in CV adoption and the effects of CV market penetration on efficiency and safety.

The research team evaluated to what extent the safety and operational objectives and benefits of Gainesville Trapezium SPaT project have been achieved. The research project had the following research goals:

1. The project obtained crash data and other available data for evaluating safety and operational performance before and after the implementation of the project in the study area to determine the impact of CV technology deployment on improving safety and operations.

2. The project identified data sources and mechanisms to be utilized for exploring the impact of deployed systems on travel time reliability, throughput, and delay.

3. The project leveraged the relevant before and after deployment data to estimate the improvement in travel time reliability by quantifying measures such as travel time index, planning time index, etc. as well as throughput and delay along study corridors where the CV technologies were deployed.

4. The project developed a CV data archive and utilized CV data for evaluation of expected benefits and provided a framework for how to utilize CV data for such deployments. The database scheme to be used for the project was developed by the research team.

5. The research team developed a data management plan, which included a data collection procedure, data storage, data retention policy suggestion to FDOT, pros and cons of various storage methods (cloud-based vs. physical facilities) for CV data obtained from a project of such scale, and other traffic data available from a typical signal system.

The rest of the document is organized as follows:

1. Chapter 2 is a detailed summary of the state of the Gainesville SPaT Trapezium before the deployment of connected vehicle (CV) applications i.e., the “before” study of operations and safety on the corridors making up the Trapezium. It provides general information regarding the study area, project network, and corridors. The next subsection summarizes the crash data analysis based on data from the Signal Four Analytics database, followed by the operational analysis results of seven signalized intersections. Detector data from CoG for each of the intersections are used to represent traffic demand in the traffic operational analysis. Finally, the travel time and speed data trends obtained along the four major corridors of the Trapezium network, are presented.

2. Chapter 3 provides a description of the software architecture and workflow we developed based on edge components, local servers, and cloud servers to collect data along the Trapezium. This section also presents a detailed description of the development of software to collect data in real-time (or near real-time) from RSUs (DSRC roadside units) and OBUs (DSRC on-board units) and store them in the cloud server.

3. Chapter 4 summarizes the development of suitable tools and software to analyze and process connected vehicle (CV) data obtained from the deployed system at regular intervals during the project.

4. Chapter 5 presents the “after” study and compares it with the “before” study presented in Chapter 2. It reviews the differences in operational performance, crashes, speed, and travel time analysis after the deployment of CV technologies. It also discusses the impact of COVID-19 pandemic-related closures on the traffic on the Trapezium.

We conclude in Chapter 6. Appendices A and B provide additional charts and data on the Trapezium, and Appendix C provides the questionnaire used during the OBU user experience interviews.

Chapter 2 – "Before" Study of Operations and Safety on the Corridor

This chapter summarizes the work conducted under Task 1 ("Before" Data Collection). The first subsection provides general information regarding the study area, project network, and corridors. The second subsection summarizes the crash data analysis based on data from the Signal Four Analytics database. The third subsection describes the operational analysis results of seven signalized intersections. Detector data from CoG for each of the intersections are used to represent traffic demand in the traffic operational analysis. The fourth subsection presents the travel time and speed data trends obtained along the four major corridors of the Trapezium network.

2.1 – Introduction

The Gainesville Trapezium study area (Figure 2-1) consists of four arterial corridors that encompass the UF campus, which is situated on the southwest side of Gainesville, FL. All four corridors are state roads that carry a significant amount of passenger car and truck traffic.

W Univ. Ave has two lanes per direction and a speed limit of 30 mph. It carries a significant amount of traffic to and from the campus. There are several restaurants and bars located on the north side of W Univ. Ave in the section from Gale Lemerand Dr to 13th St. On-street parking is available in this area. Pedestrians and bicyclists cross this corridor throughout the day, and jaywalking is frequent, especially during the evening and night hours.

The 13th St corridor is a part of the historic US-441 highway that separates the main campus from several university buildings and facilities (Norman Hall, soccer field, parking, and sorority houses) and apartment complexes. It has two lanes per direction and its speed limit is 30 mph. The Inner Road and Museum Road crossings are frequently used by students who walk and bike to and from campus. The pedestrian/bicyclist tunnel under 13th St helps connect the two areas and reduces jaywalking in its vicinity.

Archer Rd has three lanes per direction and a speed limit of 40 mph. It connects UF with Butler Plaza's numerous retail stores and restaurants as well as I-75. There are several student housing apartments on both sides of Archer Rd, as well as the UF Health Shands Hospital (near 13th St).

The 34th St corridor runs along the west side of the UF campus and has three lanes per direction. It has a speed limit of 45 mph. There are several student housing apartments along with a few restaurants and retail stores along the corridor. A bike lane is located along the corridor adjacent to the vehicular lanes.

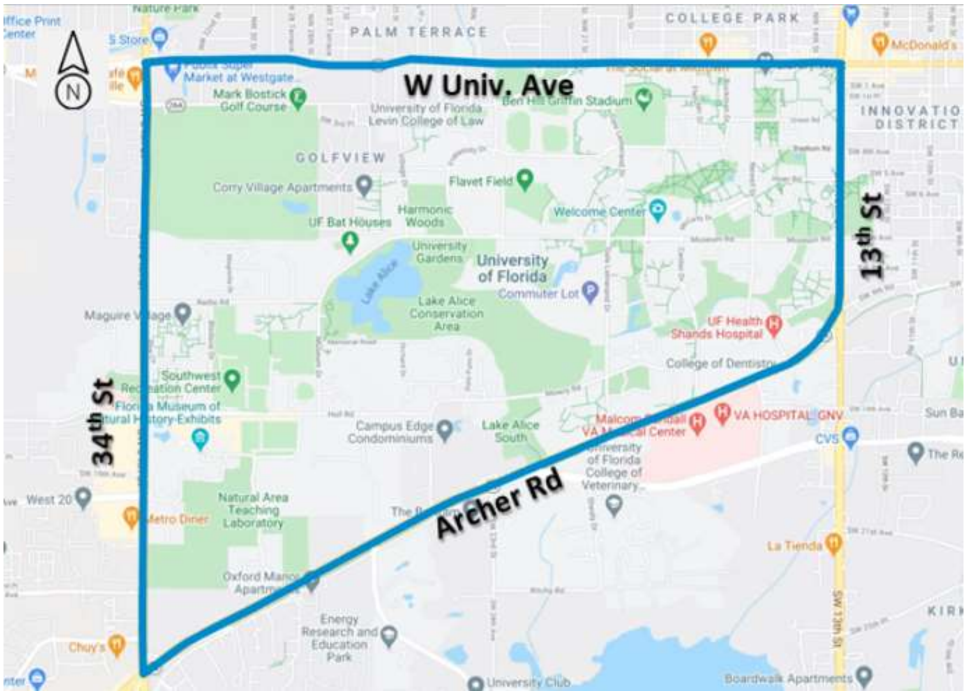

Figure 2-1. Study network consisting of four arterial corridors

2.2 – Crash Data Analysis

This section describes the safety analysis conducted using crash data for the last five years (Jan. 2015 to Dec. 2019) along the four corridors of the Trapezium network. The first subsection provides an overview of the data obtained, followed by a summary of vehicular crashes, pedestrian crashes, and bicycle crashes.

2.2.1 – Crash Data Overview

Crash data for a five-year period were extracted from the Signal Four Analytics database, which is an inventory of crash reports filed by police officers[1]. The crash data in this database include traveler type (driver, occupant, pedestrian, etc.), number and severity of injuries, violation of traffic law, time of day, day of week, alcohol or drug impairment, latitude and longitude of the crash location, vehicle characteristics, event characteristics (manner of the collision, number of vehicles involved, direction of travel), and environment (weather conditions). The crash reports along with their GIS-based crash location data were downloaded for the entire network using extraction tools available in Signal Four Analytics. Data were obtained for up to approximately 250 feet along all cross streets intersecting the four corridors.

Figure 2-2 shows the boundaries used to extract crash reports for the Trapezium network from the Signal Four Analytics database. The boundary line is drawn around the four arterials, and it includes up to 250 ft

[1] Signal Four Analytics, Inc., https://s4.geoplan.ufl.edu/

along the interesting cross streets, measured from the centerline of each of the corridors. The figure also shows total crashes by location along the network. As shown, the top three crash-prone locations are the intersections 34th St at Archer Rd, W Univ. Ave at 13th St, and W Univ. Ave at 34th St. These are the three corners of the trapezium of the project network.

Figure 2-2. Study area boundaries and crashes by location

A total of 4,774 (6 fatal) vehicle crashes, 74 (2 fatal) pedestrian crashes, and 65 bicycle crashes were recorded within the study area between Jan. 2015 and Dec. 2019. These are summarized in Table 2-1.

Table 2-1. Summary of crashes within the study network (Jan. 2015 and Dec. 2019)

Crash Type	Total Crashes	Fatal	Incapacitating	Others
Vehicle	4,774	6	78	4,690
Pedestrian	74	2	13	59
Bicycle	65	0	6	59

Figure 2-3 shows the ranking of the ten most crash-prone locations in Gainesville over the same five-year period. As shown, five of these intersections are along the Trapezium corridors. Therefore, the corridors that form the Trapezium network are critical in terms of the total number of crashes in the city.

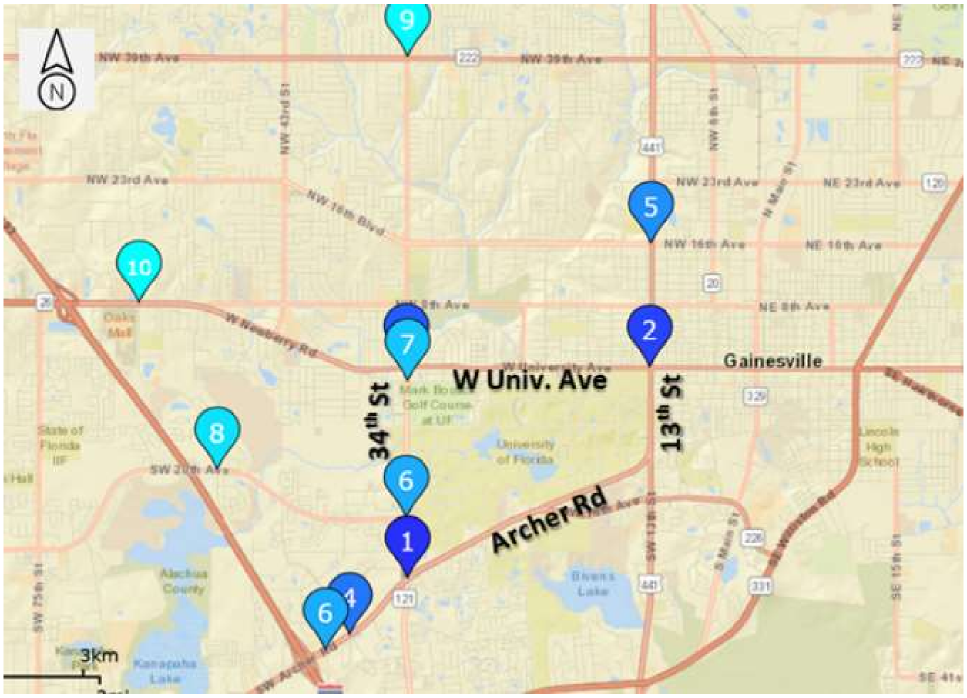

Figure 2-3. Ranking of all crash-prone locations in Gainesville (Jan. 2015 to Dec. 2019)

Figure 2-4 shows the distribution of pedestrian, bicycle, and vehicle crashes by signalized intersection and other locations within the study network. For example, at the top-left corner of the figure, for the intersection at W Univ. Ave and 34th St, "315/1/1" indicates there were 315 vehicle (only), 1 pedestrian, and 1 bicyclist crashes during the analysis period.

The top three intersections in terms of total vehicle crashes are the three corners of the Trapezium (34th St at Archer Rd; W Univ. Ave at 13th St; and W Univ. Ave at 34th St), which carry high traffic volumes.

The highest frequency of pedestrian crashes is observed at the intersections Buckman Dr at W Univ. Ave and 34th St at Archer Rd. The intersection at W Univ. Ave and 13th St has the third highest number of pedestrian crashes. Between the W Univ. Ave intersection with Gale Lemerand Dr and the one with 13th St, large numbers of UF staff and students cross W Univ. Ave to access restaurants and businesses on the north side of the arterial. The intersection of 34th St and Archer Rd is extensively used by residents of student housing in the vicinity of that location.

The highest frequency of bicycle crashes is observed along the intersections W Univ. Ave at 13th St and 34th St at 24th Ave The pedestrian and bicycle crossings are generally higher at these locations.

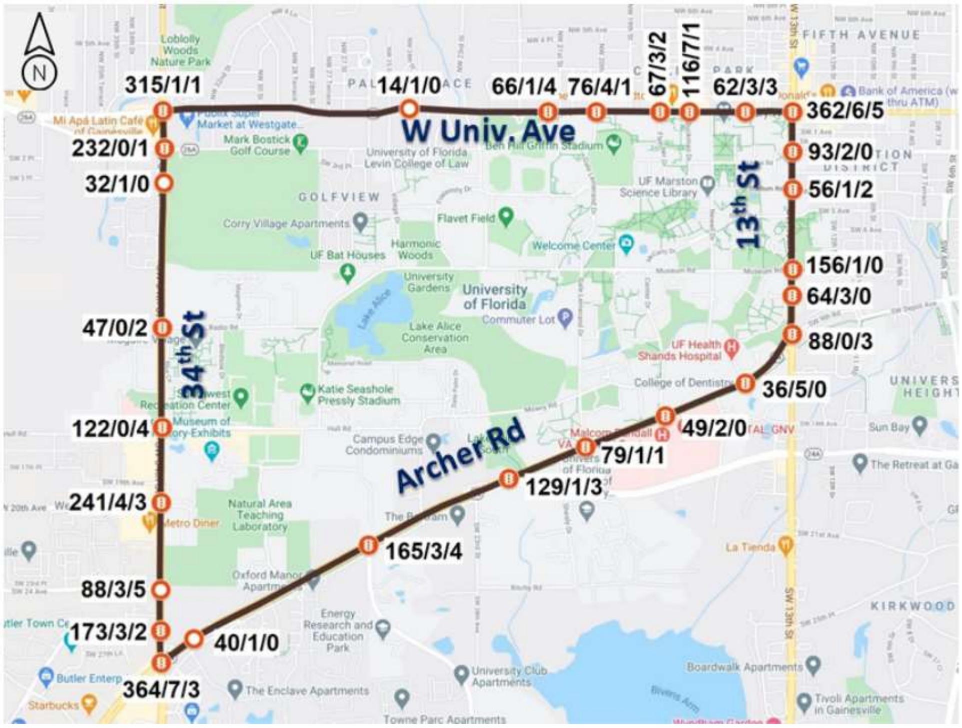

Figure 2-4. Number of vehicle (only), pedestrian, and bicycle crashes by location on the study network (format: vehicle/ped/bike)

2.2.2 – Vehicle Crashes

A total of 4,774 vehicle crashes occurred in the Trapezium network during the five-year period evaluated. These include six fatalities and 78 incapacitating injury crashes. Vehicle crashes consist of various types of collisions, including mopeds and motorcycles.

Table 2-2 shows the distribution of vehicle crashes by year. There is an increase in total vehicle crashes from year 2015 to 2019. Year 2018 had the highest number of crashes. The highest number of vehicle crashes occurred along 34th St each year of the study period.

Table 2-2. Vehicle crashes by year

Year	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
2015	160	263	225	247	895
2016	148	289	241	278	956
2017	148	298	275	222	943
2018	153	304	280	254	991
2019	163	314	273	239	989
Total	772	1,468	1,294	1,240	4,774

Table 2-3 shows the distribution of vehicle crashes by day of the week. Fridays have the highest number of crashes, and Sundays have the lowest vehicle crashes. The higher number of crashes on Friday along W Univ. Ave is due to increased activity around restaurants and bars on the north side of the arterial.

Table 2-3. Vehicle crashes by day of the week

Day of the Week	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
Sunday	65	122	84	117	388
Monday	119	184	195	151	649
Tuesday	121	202	200	168	691
Wednesday	111	218	241	210	780
Thursday	120	229	218	216	783
Friday	146	326	243	239	954
Saturday	90	187	113	139	529
Total	772	1,468	1,294	1,240	4,774

Table 2-4 provides the distribution of vehicle crashes by month of the year. The month of June shows the lowest number of crashes, most likely because of the university's summer break, during which there are limited student activities. September to November are the top three months in terms of total vehicle crashes in the network. There is generally heavier traffic during these months due to football events. October is the peak month for football, including "homecoming" games.

Table 2-4. Vehicle crashes by month of the year

Month of the year	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
January	58	107	91	100	356
February	62	124	92	101	379
March	62	120	126	105	413
April	71	125	101	108	405
May	45	110	86	81	322
June	44	100	77	65	286
July	58	103	98	81	340
August	91	109	114	113	427
September	83	145	149	141	518
October	82	163	110	125	480
November	64	137	150	129	480
December	52	125	100	91	368
Total	772	1,468	1,294	1,240	4,774

Table 2-5 provides the distribution of vehicle crashes by time of day. Generally, vehicle crashes are higher during 12 PM to 7 PM than other times of the day. The highest number of vehicle crashes occurs around 5 PM along all corridors.

Table 2-5. Vehicle crashes by time of day

Time of the Day	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
12:00 AM	11	18	22	23	74
1:00 AM	7	14	6	26	53
2:00 AM	12	10	8	55	85
3:00 AM	3	6	10	10	29
4:00 AM	2	2	1	5	10
5:00 AM	5	3	6	4	18
6:00 AM	7	7	11	5	30
7:00 AM	12	33	58	21	124
8:00 AM	34	54	72	29	189
9:00 AM	28	41	45	34	148
10:00 AM	21	39	42	23	125
11:00 AM	42	62	55	48	207
12:00 PM	55	99	73	85	312
1:00 PM	56	122	91	96	365
2:00 PM	64	112	68	81	325
3:00 PM	63	122	96	85	366
4:00 PM	53	130	118	86	387
5:00 PM	79	156	145	134	514
6:00 PM	63	132	105	101	401
7:00 PM	50	104	84	87	325
8:00 PM	37	66	61	66	230
9:00 PM	28	59	50	58	195
10:00 PM	27	50	40	48	165
11:00 PM	13	27	27	30	97
Total	772	1,468	1,294	1,240	4,774

2.2.3 – Pedestrian Crashes

Table 2-6 shows the distribution of pedestrian crashes by year. The total number of pedestrian crashes along the study network remain at similar levels with the exception of an increase in 2017. Overall, among the four arterials, W Univ. Ave had the highest number of pedestrian crashes during the analysis period. As discussed earlier, there is a high volume of pedestrians crossing this corridor.

Along Archer Rd, the pedestrian crashes dropped to zero in 2019 from a high of nine in 2017. The 13th St arterial has the lowest number of pedestrian crashes consistently every year. This might be due to the presence of the pedestrian and bicyclist tunnel north of the Inner Road crossing.

Table 2-6. Pedestrian crashes by year

Year	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
2015	1	3	1	8	13
2016	2	1	5	8	16
2017	2	5	9	4	20
2018	2	3	4	3	12
2019	1	3	0	9	13
Total	8	15	19	32	74

Table 2-7 shows the distribution of pedestrian crashes by day of the week. Although W Univ. Ave has the highest number of crashes on Fridays, for the rest of the corridors, the highest number of pedestrian crashes occur on Monday.

Table 2-7. Pedestrian crashes by day of the week

Day of the Week	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
Sunday	1	2	0	2	5
Monday	2	3	8	4	17
Tuesday	2	1	4	3	10
Wednesday	1	3	1	6	11
Thursday	0	1	1	5	7
Friday	1	2	2	7	12
Saturday	1	3	3	5	12
Total	8	15	19	32	74

Table 2-8 shows pedestrian crashes by month of the year. October has the highest number of pedestrian crashes. Pedestrian crashes are fewer during the summer months, consistent with reduced student presence on campus. These trends are also generally consistent with those for total vehicle crashes. The most pedestrian crashes occur in October, most likely due to higher levels of traffic for football games.

Table 2-8. Pedestrian crashes by month of the year

Month of the year	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
January	1	3	2	1	7
February	1	1	0	6	8
March	0	2	3	3	8
April	0	1	4	2	7
May	0	0	1	0	1
June	0	2	1	1	4
July	1	2	1	3	7
August	0	1	1	2	4
September	0	0	1	3	4
October	4	0	4	3	11
November	0	1	0	5	6
December	1	2	1	3	7
Total	8	15	19	32	74

Table 2-9 shows the time of the day distribution of pedestrian crashes. The late night period from 11 PM to 2 AM has more pedestrian crashes, especially along the W Univ. Ave corridor. The number of pedestrian crashes at 10 AM is also significant compared to other times of the day. In contrast, the total vehicle crashes are the highest during the PM peak (4-6 PM) for this network. Most vehicle crashes occur Noon–7 PM with relatively fewer crashes during the morning period.

Table 2-9. Pedestrian crashes by time of day

Time of Day	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
12:00 AM	2	0	1	2	5
1:00 AM	0	0	0	4	4
2:00 AM	0	0	0	6	6
3:00 AM	0	0	1	1	2
4:00 AM	1	0	0	1	2
5:00 AM	0	0	0	0	0
6:00 AM	0	0	2	0	2
7:00 AM	0	0	0	1	1
8:00 AM	1	0	3	0	4
9:00 AM	0	0	0	0	0
10:00 AM	0	2	2	3	7
11:00 AM	0	0	0	0	0
12:00 PM	0	0	0	0	0

Table 2-9. (continued)

Time of Day	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
1:00 PM	0	2	1	0	3
2:00 PM	0	0	2	1	3
3:00 PM	1	0	1	1	3
4:00 PM	1	4	1	0	6
5:00 PM	1	2	0	1	4
6:00 PM	1	1	1	0	3
7:00 PM	0	0	0	0	0
8:00 PM	0	1	1	2	4
9:00 PM	0	0	1	2	3
10:00 PM	0	1	0	3	4
11:00 PM	0	2	2	4	8
Total	8	15	19	32	74

2.2.4 – Bicycle Crashes

Table 2-10 provides the distribution of bicycle crashes by year. The 34th St corridor has the most bicycle crashes in the study network. The corridor has well-used bike lanes running alongside the vehicular traffic lanes. The total number of bicycle crashes has generally declined after a peak in 2017.

Table 2-10. Bicycle crashes by year

Year	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
2015	4	5	1	3	13
2016	3	8	3	2	16
2017	3	6	5	6	20
2018	0	2	3	6	11
2019	2	1	2	0	5
Total	12	22	14	17	65

Table 2-11 provides the distribution of bicycle crashes by day of the week. Bicycle crashes are the highest on Wednesdays and Fridays. The number of bicycle crashes the remaining weekdays are also higher than those recorded during weekends, likely due to higher bicycle activity during weekdays.

Table 2-11. Bicycle crashes by day of the week

Day of the Week	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
Sunday	0	2	1	1	4
Monday	4	3	1	3	11
Tuesday	1	5	3	2	11
Wednesday	1	3	3	6	13
Thursday	3	2	1	4	10
Friday	3	6	3	1	13
Saturday	0	1	2	0	3
Total	12	22	14	17	65

Table 2-12 presents the distribution of bicycle crashes by month of the year. Bicycle crashes are highest at the beginning of fall. As indicated earlier, this could be due to increased activity around campus during the fall, including football games, which result in increased traffic and larger numbers of unfamiliar drivers. The numbers are lower during spring and summer. These month-of-the year trends are also generally consistent with those for vehicle and pedestrian crashes.

Table 2-12. Bicycle crashes by month of the year

Month of the year	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
January	2	3	1	0	6
February	1	4	2	0	7
March	1	2	0	0	3
April	0	0	1	4	5
May	1	3	0	0	4
June	1	1	0	1	3
July	0	1	2	1	4
August	1	3	2	4	10
September	3	1	4	3	11
October	2	1	1	2	6
November	0	3	1	0	4
December	0	0	0	2	2
Total	12	22	14	17	65

Table 2-13 shows the number of bicycle crashes by hour of the day. Most of the crashes occurred in the evening between 5 PM and 7 PM.

Table 2-13. Bicycle crashes by time of the day

Time of Day	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
12:00 AM	0	0	0	0	0
1:00 AM	0	0	0	0	0
2:00 AM	0	0	0	0	0
3:00 AM	0	0	0	0	0
4:00 AM	0	0	0	0	0
5:00 AM	0	0	0	0	0
6:00 AM	0	0	0	0	0
7:00 AM	0	0	0	0	0
8:00 AM	1	3	1	1	6
9:00 AM	0	0	0	0	0
10:00 AM	2	3	1	2	8
11:00 AM	1	3	1	0	5
12:00 PM	0	0	1	1	2
1:00 PM	1	1	3	2	7
2:00 PM	1	1	1	0	3
3:00 PM	0	2	1	1	4
4:00 PM	1	2	1	1	5
5:00 PM	2	3	1	2	8
6:00 PM	0	2	0	4	6
7:00 PM	0	2	2	3	7
8:00 PM	1	0	1	0	2
9:00 PM	1	0	0	0	1
10:00 PM	1	0	0	0	1
11:00 PM	0	0	0	0	0
Total	12	22	14	17	65

2.3 – Traffic Operational Analysis

Based on crash data, traffic flow and pedestrian or bicyclist interactions, the research team selected seven signalized intersections at which to conduct traffic operational analysis. Four of these are located along W Univ. Ave, which has the highest number of pedestrian crashes within the study network. Two intersections are on the two corners of the Trapezium network along Archer Rd. The last intersection is 13th St and Museum Rd (8th Ave). The intersections with their IDs are given in Table 2-14, and they are shown in black circles in Figure 2-5.

Table 2-14. Selected signalized intersections with their ID

Intersection name	Intersection ID
W Univ. Ave at 34th St	S1
W Univ. Ave at 20th Terr (Gale Lemerand Dr)	S2
W Univ. Ave at 17th St	S3
W Univ. Ave at 13th St	S4
SW 8th Ave at 13th St	S5
SW Archer Rd at 13th St	S6
SW Archer Rd at 34th St	S7

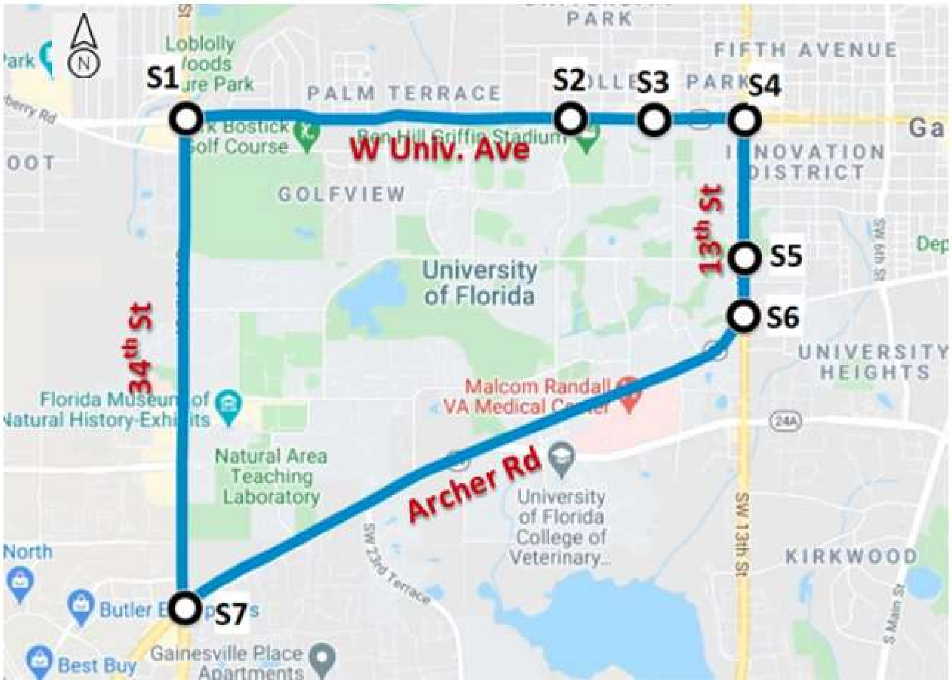

Figure 2-5. Traffic analysis intersections

The next subsection summarizes the data collected, followed by an overview of the traffic operational analysis results.

2.3.1 – Data Collection

To conduct operational analyses at the seven intersections, the research team obtained geometric data, traffic flow data, and signal timing data.

2.3.1.1 – Geometric Data

Geometric data were obtained using the aerial view from Google Maps and are provided in Appendix A. Table 2-15 shows an example of the information obtained for the intersection at W Univ. Ave and 13th St (Figure 2-6). All approaches have an exclusive through lane and a shared through and right-turn lane. There is no on-street parking along any of the approaches. The approach grade is assumed to be 0% for all approaches.

Table 2-15. Geometric design information for W Univ. Ave and 13th St

Geometric Data	EB			WB			NB			SB		
	L	Th	R	L	Th	R	L	Th	R	L	Th	R
Number of lanes	4			3			3			3		
Average lane width (ft)	11			11			11			11		
Number of receiving lanes (ln)	2			2			2			2		
Turn bay length (ft)	450	999	240	240	999	—	310	999	—	470	999	—
Presence of on-street parking	0			0			0			0		
Approach grade (%)	0			0			0			0		
Total walkway width (ft)	10			10			10			10		
Crosswalk width (ft)	10			10			10			10		
Crosswalk length (ft)	70			70			75			70		
Corner radius (ft)	30			30			35			20		

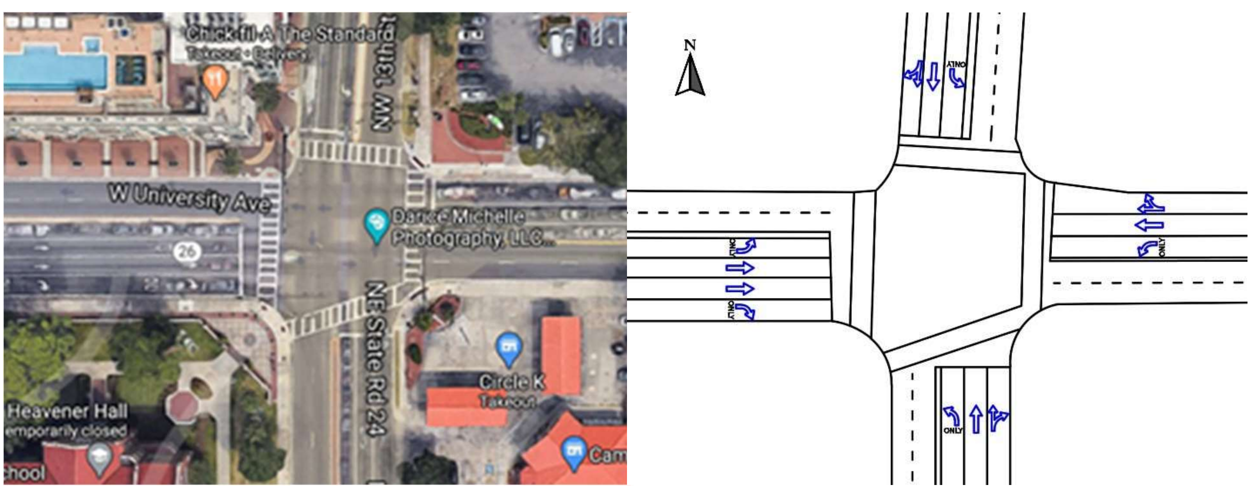

Figure 2-6. Layout and lane configuration of W Univ. Ave and 13th St

2.3.1.2 – Traffic Data

Traffic data were obtained using the City of Gainesville detectors. The research team mapped the detectors to the phases of the signalized intersections to obtain the respective turning movements.

Missing and erroneous data were reconciled in consultation with City of Gainesville staff. For right-turn and through shared lanes, we assumed ratios of right-turn traffic to total lane traffic consistent with previous projects, when available. For example, data from the project "Before-and-After Study of Gainesville Pedestrian-Bicyclists Connected Vehicle Pilot"[2] were used to calculate the ratios of right-turn traffic to total traffic for intersection S4. The ratios for intersection S3 were estimated using turning movement data from the "One-Way Pairs Study" conducted by CoG in 2019 (CHW, 2019).

For locations without previously collected data, the research team collected a sample of turning movements using video from the Bosch traffic monitoring cameras. Data observed from the Bosch traffic camera at intersection S7 were used to estimate the ratios "right turn to lane total" for shared lanes at this intersection. S1 did not have any data from previous studies, and there were issues focusing the traffic camera on the approach of interest. Hence, the same "right turn to lane total" ratio was used for shared lanes at S1 as was observed at S4 as both these intersections are on the same corridor with similar traffic patterns.

Data were collected during weekdays (Tuesday, Wednesday, and Thursday) during the last week of January 2020 and the first week of February 2020. Therefore, the data are not affected by changes in travel patterns due to the COVID-19 pandemic. The research team collected data for the AM peak (7:30 AM to 8: 30 AM), off-peak (12 PM to 1 PM) and PM peak (4:30 PM to 5:30 PM) time periods. A total of sixty minutes (study period) of detector counts was extracted for all intersections at 15-min (analysis period) intervals for each of these three study periods.

Input data were entered into the Highway Capacity Software (HCS7) for the AM peak, off-peak, and PM peak study periods. The input data tables for all signalized intersections are provided in Appendix A. As an example, Table 2-16 summarizes the traffic throughput and characteristics obtained for W Univ. Ave at 13th St for the PM peak hour. Generally, all approaches to the intersection at W Univ. Ave and 13th St intersection carry high volumes during the PM peak. Right turns on red are not allowed for any of the approaches. A high number of pedestrians use the north approach crosswalk resulting in long queues for the eastbound right-turning vehicles. Pedestrian counts from the UF AID project were used to determine the pedestrian flow rate.

[2] Known as the UF AID project. A project of the Southeastern Transportation Research, Innovation, Development and Education Center (STRIDE), funded by the Florida Department of Transportation, 2019–2023.

Pedestrian flow for the intersection S3 was obtained from "One-Way Pairs study" referenced earlier. Pedestrian counts from other intersections were assumed to be 100 ped/h along major roads and 50 ped/h along minor roads. Other traffic characteristics, including local bus stopping rates, percentage of heavy vehicles, and upstream filtering adjustment ratios, were assumed based on site characteristics (see Appendix A) and default values suggested in the HCM, 6th Edition.

Table 2-16. Traffic Flow and Characteristics at W Univ. Ave and 13th St

Traffic Characteristics	EB			WB			NB			SB		
	L	Th	R	L	Th	R	L	Th	R	L	Th	R
Traffic flow rate (veh/h)	184	504	216	116	372	84	144	1100	328	76	488	100
RTOR flow rate (veh/h)	0			0			0			0		
Percentage heavy vehicles	3	3	3	3	3	3	3	3	3	3	3	3
Platoon ratio	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Upstream filtering adjustment factor	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Initial queue (veh)	0	0	0	0	0	0	0	0	0	0	0	0
Pedestrian flow rate (ped/h)	104			204			76			212		
Bicycle flow rate (bicycles/h)	0			0			0			0		
On-Street parking maneuver rate (veh/h)	0			0			0			0		
Local bus stopping rate (buses/h)	2			2			2			2		
Mid-segment 85th percentile speed (mi/h)	30			30			30			30		
Number of right-turn islands	0			0			0			0		

2.3.1.3 – Signal Timing Data

Signal timing data are available from the CoG Advanced Traffic Management System (ATMS) database. For example, the signal timing data of W Univ. Ave and 13th St are shown in Table 2-17. The signal timings for all signalized intersections are provided in Appendix A.

Table 2-17. Signal timing data for W Univ. Ave and 13th St

Phase Information	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Maximum Green (G_{max}) or Phase Split, s	25	45	25	45	30	70	25	55
Yellow Change Interval (Y), s	3.7	3.7	3.7	3.7	3.8	3.8	3.8	3.8
Red Clearance Interval (R_c), s	2	2	2	2	2	2	2	2
Minimum Green (G_{min}), s	7	12	7	12	7	12	7	12

Table 2-17. (continued)

Phase Information	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Start-Up Lost Time (*lt*), s	2	2	2	2	2	2	2	2
Extension of Effective Green (*e*), s	2	2	2	2	2	2	2	2
Passage (*PT*), s	3	3.5	3	3.5	3	3.5	2.5	3.5
Recall Mode	Off	Off	Off	Off	Off	Off	Off	Off
Dual Entry	No	Yes	No	Yes	No	Yes	No	Yes
Walk (*Walk*), s	——	7	——	7	——	7	——	7
Pedestrian Clearance Time (*PC*), s	——	24	——	22	——	22	——	23

2.3.2 – Traffic Operational Analysis Results

The operational analysis for the signalized intersections was conducted using the HCS software. The analysis results for all seven intersections are presented in Table 2-18. As shown, the two worst-performing intersections are W Univ. Ave at 13th St and Archer Rd at 34th Ave, particularly during the PM peak. Also, given the flows used as input represent throughput rather than demand (which considers upstream queues), field conditions are likely worse than shown in the analysis results. The detailed HCS analysis and results of all the signalized intersections are provided in Appendix A.

Table 2-18. HCM analysis results for the study signalized intersections

Intersection name	Intersection ID	Delay (s/veh)			Motorized Vehicle LOS		
		AM peak	Off-peak	PM peak	AM peak	Off-peak	PM peak
W Univ. Ave at 34th St	S1	41.9	41.7	48.1	D	D	D
W Univ. Ave at 20th Terr	S2	13.6	13.3	14.3	B	B	B
W Univ. Ave at 17th St	S3	40.7	41.8	38.2	D	D	D
W Univ. Ave at 13th St	S4	49.8	40.5	62.1	D	D	E
SW 8th Ave at 13th St	S5	31.8	28.1	26.9	C	C	C
SW Archer Rd at 13th St	S6	38.9	29.8	35.7	D	C	D
SW Archer Rd at 34th St	S7	55.7	62.7	91.0	E	E	F

A map of the study intersections and their LOS during the PM peak is shown in Figure 2-7. The four intersections at the corners of the Trapezium operate in oversaturated (S7) or nearly oversaturated (S1, S2, S4) conditions. The remaining intersections (S2, S3, and S6) operate in better LOS, most likely because the other four intersections act as meters for vehicles entering the network.

Figure 2-7. LOS map of selected signalized intersections during the PM peak period

2.4 – Speed and Travel Time Analysis

Travel time and speed data along several corridors in Gainesville are available through the BlueARGUS dataset operated by TrafficCast International, Inc. This dataset provides speed and travel times for the four corridors of the Trapezium network. Data were obtained for the period January 25 to February 9, 2020 (prior to the COVID pandemic).

There are six different sections along the Trapezium network for which BlueARGUS datasets are provided. These sections of the corridor are shown in Figure 2-8. Speeds along these sections of the corridors are discussed in this part of the report. Travel time data and graphs are provided in Appendix B.

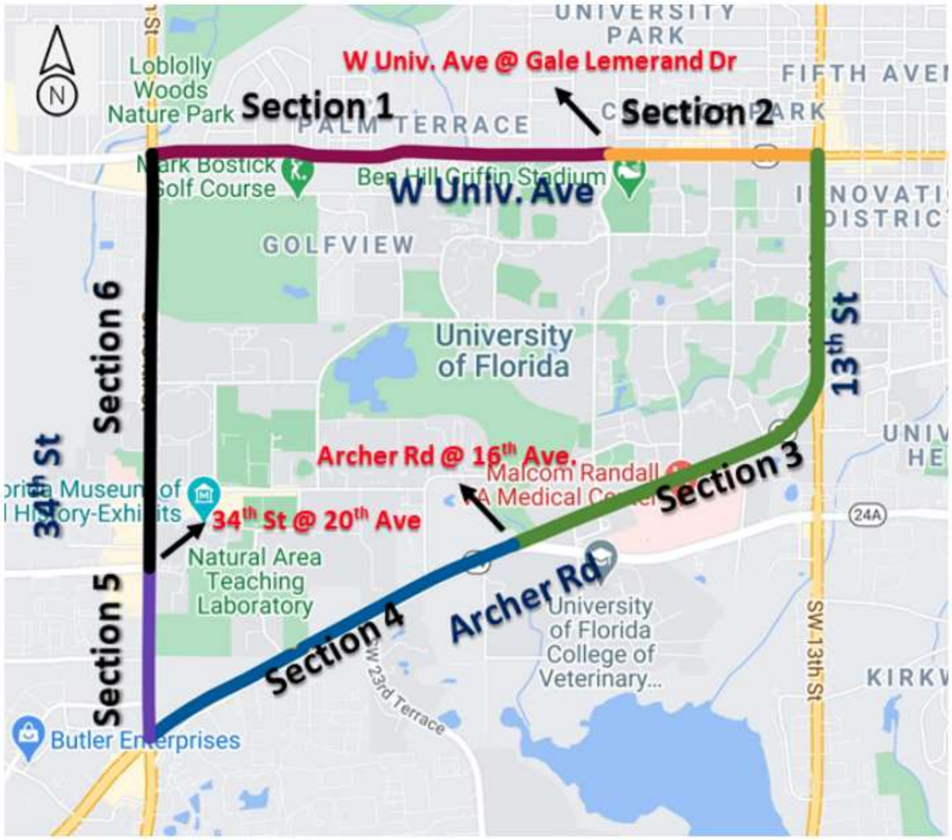

Figure 2-8. Speed data sections of Trapezium network

2.4.1 – W Univ. Ave (West) – Section 1

W Univ. Ave forms the north border of the University of Florida campus. This section has a speed limit of 30 mph. Section 1 runs from 34th St to Gale Lemerand Dr. The traffic volumes along this section are usually lower than those along the more easterly Section 2. The north side of Section 1 is predominantly residential. Table 2-19 shows the average speeds during weekdays (Tuesday, Wednesday, and Thursday), Friday, and weekend (Saturday and Sunday) along Section 1 for both the WB and EB directions. These have the following trends:

- The WB average speeds during weekdays and Friday are higher than the EB average speeds during the same times.
- The speeds are higher during the weekend than weekdays for the EB. However, speeds are roughly similar during weekdays and weekend for the WB. This suggests the WB direction is equally used throughout the week, probably because of the Oaks Mall and other shopping to the west of the university.
- The highest WB speeds are observed during the AM peak, and the lowest EB speeds are observed

during the PM peak. Generally, the PM peak period is the most congested for this section. The average speed of Friday PM peak time is exceptionally low for the EB direction, potentially due to traffic heading out of town for the weekend.

Table 2-19. Average speeds (in mph) along W Univ. Ave (West) – Section 1

Time of Day	Section 1					
	Eastbound			Westbound		
	Weekday	Friday	Weekend	Weekday	Friday	Weekend
AM peak	**24**	**24**	**34**	**33**	**34**	**33**
Off-peak	**28**	**28**	**33**	**32**	**29**	**31**
PM peak	**23**	**16**	**33**	**28**	**22**	**32**

2.4.2 – W Univ. Ave (East) – Section 2

The east part of the W Univ. Ave section (Section 2) runs from Gale Lemerand Dr to 13th St. There are several restaurants and bars along Section 2 that are frequented by university staff and students. This section also serves as a popular nightlife spot. Jaywalking on Section 2 is frequent, especially during the evening and night hours. Table 2-20 provides average speeds for this section during weekdays (Tuesday, Wednesday, and Thursday), Friday, and weekend (Saturday and Sunday). The following were observed:

Generally, average speeds during weekdays are lower than average weekend speeds. However, average speeds during weekdays are similar to the speed limit during weekends for the AM peak period in both directions.

The EB direction has slightly lower average speeds during the weekend off-peak periods. This is due to student activities as well as the presence of restaurants and bars. Similar to Section 1, Friday PM peak speeds are the lowest among all time periods examined.

Table 2-20. Average speeds (mph) along W Univ. Ave (East) – Section 2

Time of Day	Section 2					
	Eastbound			Westbound		
	Weekday	Friday	Weekend	Weekday	Friday	Weekend
AM peak	26	28	26	29	30	31
Off-peak	24	23	23	23	21	26
PM peak	20	15	24	21	18	25

2.4.3 – 13th St and Archer Rd (East) – Section 3

13th St is located along the east border of the UF main campus, which is part of the historic US-441 highway. There are several university buildings and facilities (Norman Hall, soccer field, parking, and sorority houses) as well as apartment complexes along this section.

Two important roadways within the university campus (Inner Road and Museum Road) intersect this section. These roadways are frequently used by students, who walk and bike to and from campus, especially during the daytime. The pedestrian/bicyclist tunnel under 13th St helps connect the two areas and reduces jaywalking in its vicinity.

Table 2-21 shows the weekdays (Tuesday, Wednesday and Thursday), Friday, and weekend average speeds for the section 13th St at Archer Rd (East). Due to lack of Bluetooth travel time stations matching the exact coordinates of 13th St, the section from Archer Rd at 16th Ave to W Univ. Ave at 13th St was used. Both directions were analyzed:

- NE bound (Archer Rd at 16th Ave to W Univ. Ave at 13th St)
- SW bound (W Univ. Ave at 13th St to Archer Rd at 16th Ave)

Table 2-21. Average speeds (mph) along 13th St and Archer Rd (East) – Section 3

Time of Day	**Section 3**					
	Northeast bound			**Southwest bound**		
	Weekday	Friday	Weekend	Weekday	Friday	Weekend
AM peak	17	20	22	25	23	29
Off-peak	18	18	21	21	21	25
PM peak	13	12	21	19	17	23

The following trends were observed:

- The average speeds are slightly lower along the NEB direction than the SWB direction. The traffic volumes in the NEB direction are higher than in the SWB direction. A small portion of the SB traffic along 13th St turns right at the intersection of Archer Rd and 13th St without any delay, thus resulting in lower travel time for the SWB direction. Additionally, the presence of the left turns from Archer Rd to 13th St increases the travel time for the NEB direction.
- The speeds are higher during the weekend than those during weekdays along both directions. The lowest speeds are generally observed on Fridays, when traffic is generally the highest around campus.
- The highest speeds are observed in the AM peak, and lowest speeds are observed in the PM peak period.

2.4.4 – Archer Rd (West) – Section 4

Archer Rd is situated on the south border of the UF campus. There are several university buildings, including UF Health Shands (next to 13th St) on the east part of Section 4. There are several housing complexes on and near the section, along with Butler Plaza's retail stores, dining, and entertainment. Beyond 34th St, Archer Rd intersects with I-75, a few miles southeast of the UF campus. This roadway provides access to the university and connects I-75 to downtown Gainesville. The speed limit along this section is 40 mph.

Table 2-22 provides the average speeds for this section during weekdays (Tuesday, Wednesday, and Thursday), Friday, and weekends. The following was observed:

- Lower speeds are observed during weekdays than weekends along both directions. The weekday average speed is lowest during the PM peak period for WB traffic and during the AM peak period for EB traffic. This is consistent with traffic approaching the university in the morning and departing in the afternoon.
- During weekends, the speeds are very close to the speed limit for the EB direction. This section of the Archer Rd is not used much during weekends, as there are no retail or entertainment attractions along this section.
- Similarly to the data obtained for the other sections, the lowest speeds are observed on Friday during the PM.

Table 2-22. Average speeds (in mph) along Archer Rd (West) – Section 4

Time of Day	Section 4					
	Eastbound			Westbound		
	Weekday	Friday	Weekend	Weekday	Friday	Weekend
AM peak	22	27	42	29	27	39
Off-peak	31	29	41	28	24	33
PM peak	24	23	41	13	11	29

2.4.5 – 34th St (South) – Section 5

The south section of 34th St (Section 5) is along the western border of the UF campus, between Archer Rd and SW 20th Ave. The speed limit on this arterial is 45 mph. There are several restaurants and stores along Section 5. The traffic volume along this section is the highest among all sections of the Trapezium network. Table 2-23 shows the average speeds along the section for weekdays (Tuesday, Wednesday and Thursday), Friday, and weekends. The following were observed:

- Average speeds along this section are significantly below the speed limit along both directions. This is likely due to heavy traffic at the intersections with Windmeadows Blvd. and 34th St. Windmeadows Blvd carries significant amounts of traffic to Butler Plaza.
- Speeds are slightly higher during the weekend than weekdays for both directions. The lowest average speed was observed on Fridays for the SB direction.
- Operations during the PM peak are significantly worse (particularly in the SB direction) than operations along all other sections. This is due to traffic departing UF to access I-75 and suburban areas around Gainesville.

Table 2-23. Average speeds (in mph) along 34th St (South) – Section 5

Time of Day	Section 5					
	Northbound			**Southbound**		
	Weekday	Friday	Weekend	Weekday	Friday	Weekend
AM peak	30	30	34	28	32	35
Off-peak	28	29	30	25	19	25
PM peak	29	26	29	16	8	23

2.4.6 – 34th St (North) – Section 6

The north part of 34th St is located between SW 20th Ave and W Univ. Ave (Section 6). The area around this section has several student housing complexes. Table 2-24 provides the average speeds for this section for weekdays (Tuesday, Wednesday and Thursday), Friday, and weekend (Saturday and Sunday). The following are observed:

- Average speeds along this section are relatively higher than Section 5 but still lower than the speed limit.
- Generally, average speeds are higher along the SB than the NB. The NB direction along this section includes two intersections (34th St at W Univ. Ave; 34th St at SW 2nd Ave) with heavy demands.
- Weekday average speeds are somewhat lower than those during weekends.

Table 2-24. Average speeds (in mph) along 34th St (North) – Section 6

Time of Day	Section 6					
	Northbound			Southbound		
	Weekday	Friday	Weekend	Weekday	Friday	Weekend
AM peak	26	27	35	35	36	39
Off-peak	28	27	29	35	32	34
PM peak	22	22	27	22	16	33

2.4.6.1 – Overall Findings

Table 2-25 shows the average speeds by section. Overall, the study network is heavily travelled. Generally, the PM Peak period has the lowest speeds. Friday PM peak speeds are the lowest along all sections. Overall, speeds during the weekdays are lower than speeds during the weekend.

Table 2-25. Average speed (mph) along all sections, with section numbers shown in parentheses

Time of Day	W Univ. Ave (1+2)						13th St and Archer Rd (East) (3)					
	Eastbound			Westbound			Northeast bound			Southwest bound		
	Week-day	Fri-day	Week-end	Week-day	Fri-day	Week-end	Week-day	Fri-day	Week-end	Week-day	Fri-day	Week-end
AM peak	25	26	30	31	32	32	17	20	22	25	23	29
Off-peak	26	26	28	28	25	29	18	18	21	21	21	25
PM peak	22	15	28	24	20	28	13	12	21	19	17	23
Time of Day	**34th St (5+6)**						**Archer Rd (West) (4)**					
	Northbound			**Southbound**			**Eastbound**			**Westbound**		
	Week-day	Fri-day	Week-end	Week-day	Fri-day	Week-end	Week-day	Fri-day	Week-end	Week-day	Fri-day	Week-end
AM peak	28	28	35	32	34	37	22	27	42	29	27	39
Off-peak	28	28	30	30	25	29	31	29	41	28	24	33
PM peak	25	24	28	19	12	28	24	23	41	13	11	29

2.4.7 – Travel Time Reliability

Two travel time reliability indices, travel time index and planning time index, for three peak periods of weekdays were estimated and shown in Table 2-26 and Table 2-27, respectively. Travel time data for the period January 27 to February 7, 2020 obtained from the BlueARGUS database were used.

Travel time index (TTI) is the ratio of mean travel time during the analysis period to the travel time at free-flow condition. Travel time during free-flow conditions was assumed to be equal to the average minimum travel time during weekdays. TTI indicates the travel time required during congestion compared to the ideal, or free-flow travel time. For example, a TTI of 1.5 means that if the free-flow travel time is 100 s, it takes 150 s (1.5 × 100 s = 150 s) for the same trip during the analysis period. Table 2-26 shows the TTI for each section along the Trapezium network.

Table 2-26. Travel time index for the road sections

Direction	Section	AM peak	Off-peak	PM peak
Clockwise	Section 1 (EB)	2.03	1.61	2.21
	Section 2 (EB)	1.84	2.05	2.65
	Section 3 (SWB)	2.05	2.27	2.57
	Section 4 (WB)	2.10	2.24	4.77
	Section 5 (NB)	2.04	2.14	2.13
	Section 6 (NB)	2.27	2.15	2.82
Anti-clockwise	Section 1 (WB)	1.54	1.62	1.96
	Section 2 (WB)	1.74	2.35	2.52
	Section 3 (NEB)	1.95	1.94	2.68
	Section 4 (EB)	2.85	1.92	2.49
	Section 5 (SB)	3.07	3.94	6.80
	Section 6 (SB)	1.57	1.65	3.08

Planning time index (PTI) is the ratio of the 95th percentile travel time to the travel time at free-flow speed. This ratio indicates the total travel time that one should plan to ensure on-time arrival. The extra time, also known as buffer time, is added to the average travel time to account for unexpected delays. For example, a PTI of 1.8 indicates that if the travel time during free-flow conditions is 100 s, one should plan to leave 80 s (1.8 × 100 s = 180 s; 180 s – 100 s = 80 s) earlier during the analysis period to ensure on-time arrival. Table 2-27 shows the PTI for each section of the project network.

Table 2-27. Planning time index for the road sections

Direction	Section	AM peak	Off-peak	PM peak
Clockwise	Section 1 (EB)	3.21	1.82	4.06
	Section 2 (EB)	2.25	2.73	5.40
	Section 3 (SWB)	3.04	2.97	4.02
	Section 4 (WB)	2.52	2.82	6.98
	Section 5 (NB)	2.76	2.93	3.03
	Section 6 (NB)	3.07	2.70	3.93

Table 2-27. (continued)

Direction	Section	AM peak	Off-peak	PM peak
Anti-clockwise	Section 1 (WB)	1.91	2.07	3.35
	Section 2 (WB)	2.22	3.16	3.24
	Section 3 (NEB)	2.45	2.64	3.63
	Section 4 (EB)	5.34	2.37	2.87
	Section 5 (SB)	4.91	6.51	12.60
	Section 6 (SB)	1.80	2.20	5.40

Generally, both reliability indices are highest during the PM peak period. Consistent with the previous analysis, PM peak periods have the worst performance. Applications from connected vehicle (CV) technology have the potential to improve commuting experience within the Trapezium network.

2.5 – Conclusions

The "before" study was conducted using crash data, Bluetooth travel times, and traffic counts. In summary the following can be concluded:

2.5.1 – Safety Analysis

- Crash data over a period of five years (2015–2019) were used to conduct safety analysis.
- Five of the top ten intersections in terms of crash frequency in the city of Gainesville are part of the Trapezium network.
- Regarding vehicular crashes, these mostly occur along 34th St (which has the highest speed limit) followed by Archer Rd. and then 13th St. September to November (the college football season) are the months with the highest number of crashes. Friday evenings, when traffic is the highest, have the highest frequency of crashes.
- Regarding pedestrian crashes, these mostly occur on W Univ. Ave, which is used by pedestrians to access restaurants and bars north of the campus. Most of these crashes occur on Friday and Saturday late nights (10 PM to 2 AM). This area is known for pubs and bars, with high pedestrian activity at this time. There is also a clear spike in pedestrian crashes in the month of October, when traditionally most of the home football games occur.
- Regarding bicyclist crashes, these mostly occur along 34th St where bicyclists share the road with high-speed vehicular traffic (45 mph), followed by W Univ. Ave and then Archer Rd. Similar to other types of crashes, the months of August and September have the highest crash frequency.

- 13th St. has the lowest number of crashes overall. There are two reasons that may contribute to this. First, the speed limit on 13th St. is the lowest (30 mph); second, a large proportion of pedestrians and bicyclists crossing this road use the tunnel near the Inner Rd intersection.
- Years 2017–2018 had the worst crash record in the five years analyzed for this project. While the bicyclist crashes went down in 2019, both vehicular and pedestrian crashes remained similar or marginally increased compared to previous years.

2.5.2 – Traffic Operational Analysis

- The research team identified seven critical signalized intersections at which to conduct traffic operational analysis.
- Traffic data were obtained using City of Gainesville detectors. The research team mapped the detectors to the phases of the signalized intersections to obtain the respective turning movements. Missing and erroneous data were reconciled in consultation with City of Gainesville staff.
- HCM analysis was conducted using the HCS software. LOS was determined for the seven critical intersections during AM peak, off-peak, and PM peak.
- All four intersections located at the corners of the Trapezium were oversaturated (S7) or nearly oversaturated (S1, S2, S4). Other Trapezium intersections operated better, most likely because the intersections at the corners of the Trapezium act as meters and restrict the traffic entering the rest of the network.
- The PM peak is the most congested time period for the Trapezium network, with the intersection at Archer Rd and 34th St. at LOS F and the intersection at 13th St and W Univ. Ave at LOS E.

2.5.3 – Travel Time Analysis

- The travel time index (TTI) and planning time index (PTI) were calculated to capture travel time reliability. These indices show high variability in travel times, particularly during the AM and PM peak periods.

Chapter 3 – Development of Software for Data Collection

This section presents the supporting tasks and deliverables for Task 2, “Work with Siemens Mobility, Inc., and the CoG to Develop Software to Collect Data from the Gainesville Trapezium SPaT Project,” for FDOT project BDV31-977-117, “Data Analytics and Evaluation of the Gainesville Trapezium Connected Vehicle Signal Phasing and Timing (SPaT) Deployment Project.” The specific subtasks are outlined as follows along with the section numbers in the report that pertain to these subtasks.

1. Development of software to collect data in real-time (or near real-time) from RSUs and store it in the cloud server. Suitable communication mechanisms were developed to receive appropriate data from the CoG.
2. Data have also been collected by Florida A&M University and Florida State University researchers on SPaT and MAP. As part of this project, the research team worked with them to leverage their data collection studies and processes in developing suitable software adapters for storing historical and real-time data .
3. An appropriate mechanism was developed to test the relationship of stored MAP data and data sent to the OBUs. Initial tests were performed to ascertain accuracy in the data collection process.
4. In addition to the SPaT application, this project deployed additional CV applications, such as (1) Red Light Violation Warning, (2) Wrong Way Entry, (3) Curve Speed Warning, (4) Emergency Electronic Brake Lights, (5) Forward Collision Warning, (6) Intersection Movement Assist, (7) Work Zone Warning, (8) Do Not Pass Warning, (9) Speed Limit Warning, (10) Emergency Vehicle Preemption, (11) Wi-Fi/Bluetooth Travel Time Data, (12) Probe Enabled Traffic Monitoring/Virtual detectors, (13) Pedestrian to Vehicle Communication/Cyclist to Vehicle Communication, (14) Transit Signal Priority, (15) Pedestrian Collision Warning, and (16) Priority Green Light.

The research team helped FDOT in documenting the functionalities and effectiveness of these applications. The research team also provided FDOT with lessons learned regarding the effectiveness of such CV deployment projects.

3.1 – Introduction

Here, we detail the progress and achieved objectives in our work with Siemens Mobility, Inc., and the City of Gainesville to develop software for collecting data from the Gainesville Trapezium SPaT Project. Siemens Mobility, Inc., furnished, installed, and integrated 27 roadside units (RSUs) at the 27 Trapezium signals. These RSUs were tested initially with six vehicles equipped with on-board units (OBUs). The RSUs and OBUs connected with each other using dedicated short-range communication (DSRC), which was an

802.11p-based wireless communication technology operating in the 5.9-GHz band. DSRC enables highly secure, high-speed direct communication between vehicles and the surrounding infrastructure, without involving any cellular infrastructure.

DSRC enables the transmission of data at high speeds (over one-way or two-way short-range to medium-range wireless channel) which is critical for communication-based active safety applications to prevent traffic incidents. There are two types of DSRC: vehicle-to-vehicle (V2V) and vehicle–to-infrastructure (V2I). DSRC makes it possible to have a protected wireless interface constancy with short time delays and latency, while being highly robust under extreme weather conditions.

Some examples of DSRC-based applications that aid in traffic management and public safety are:

1. Red Light Violation Warning
2. Wrong Way Entry
3. Curve Speed Warning
4. Emergency Electronic Brake Lights
5. Forward Collision Warning
6. Intersection Movement Assist
7. Work Zone Warning
8. Do Not Pass Warning
9. Speed Limit Warning
10. Emergency Vehicle Preemption
11. Wi-Fi or Bluetooth Travel Time Data
12. Probe-Enabled Traffic Monitoring and Virtual Detectors
13. Pedestrian-to-Vehicle Communication and Cyclist-to-Vehicle Communication
14. Transit Signal Priority
15. Pedestrian Collision Warning
16. Priority Green Light.

These various traffic applications can enhance public safety for normal vehicles and also especially in the context of connected vehicles, by providing an ideal setting for connected vehicle safety and mobility applications.

In the rest of this chapter, we will describe the software developed to connect to RSUs and download the upstream and downstream messages and an UI developed to display a summary of the messages received from the various RSUs and the connectivity status of each RSU.

3.2 – Connecting to RSUs

There are two ways to connect to the RSUs: the first uses the RSU Web application, and the second uses Java WebSocket APIs. We describe both processes in this section.

3.2.1 – Web Interface to Connect to the RSUs

Figure 3-1 shows the logging page of the Web interface of the RSU Control Application from Siemens Mobility, Inc.

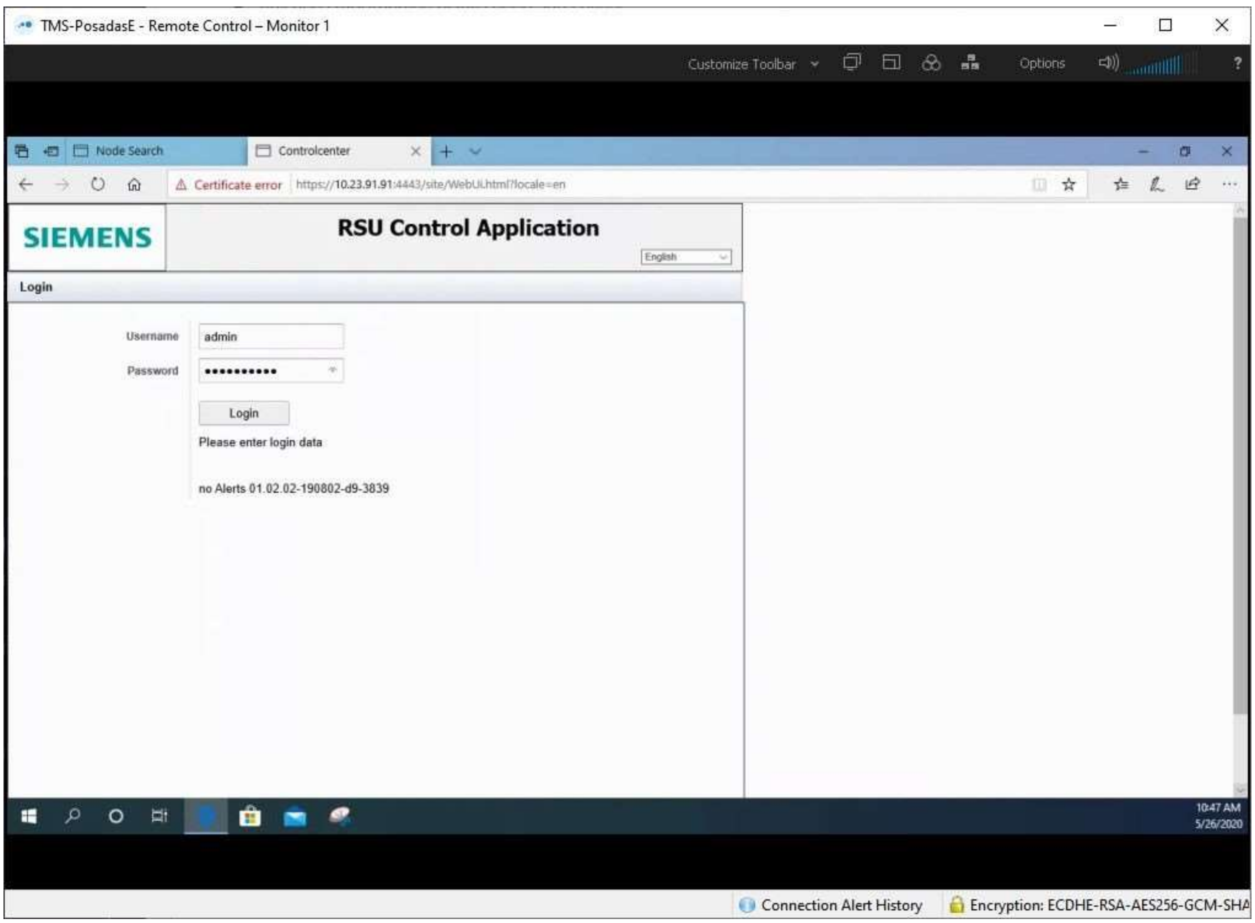

Figure 3-1. Log-in page of the RSU Control Application; authorized users can use this interface to configure the RSU properties.

An RSU uses a local Wi-Fi hot spot for remote maintenance or travel time applications. The RSU control application enables the authorized users to configure the properties of an RSU specified using its IP address and on port 4443. Thus, all the RSUs may be managed from a central location using the RSU IP addresses.

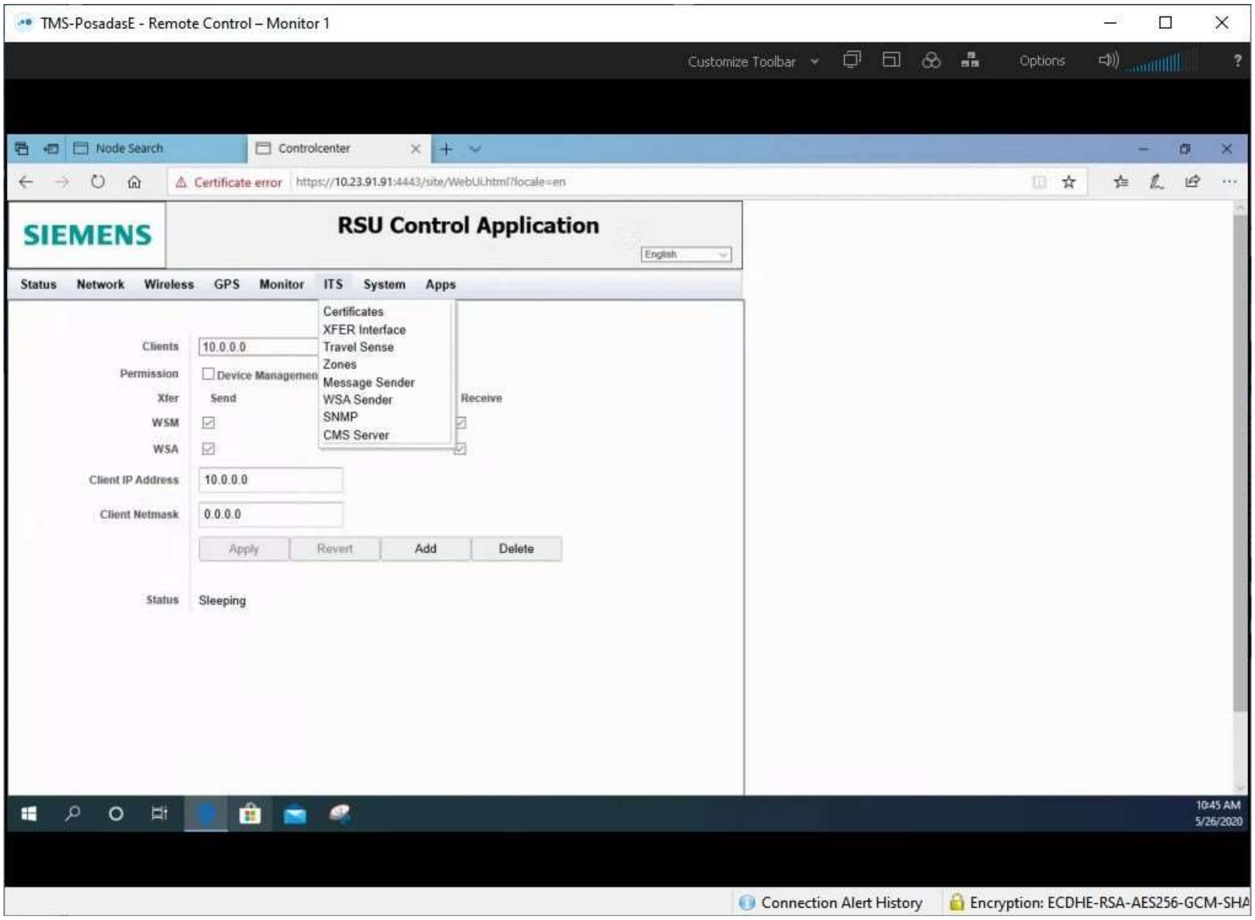

Figure 3-2. Settings for XFER interface of the roadside unit

An RSU uses an optional LTE cellular radio for long distance backhaul to the central system, and this is used for data upload and download. Using the control panel, we can connect to the RSUs to set up the RSU properties enabling data upload and download. The users have to select ITS->XFER Interface (as shown in Figure 3-2) to set up properties such as Client IP address and Client Netmask and to check the boxes for WSM and WSA so the RSUs are enabled to forward the message stream to the client via the XFER interface.

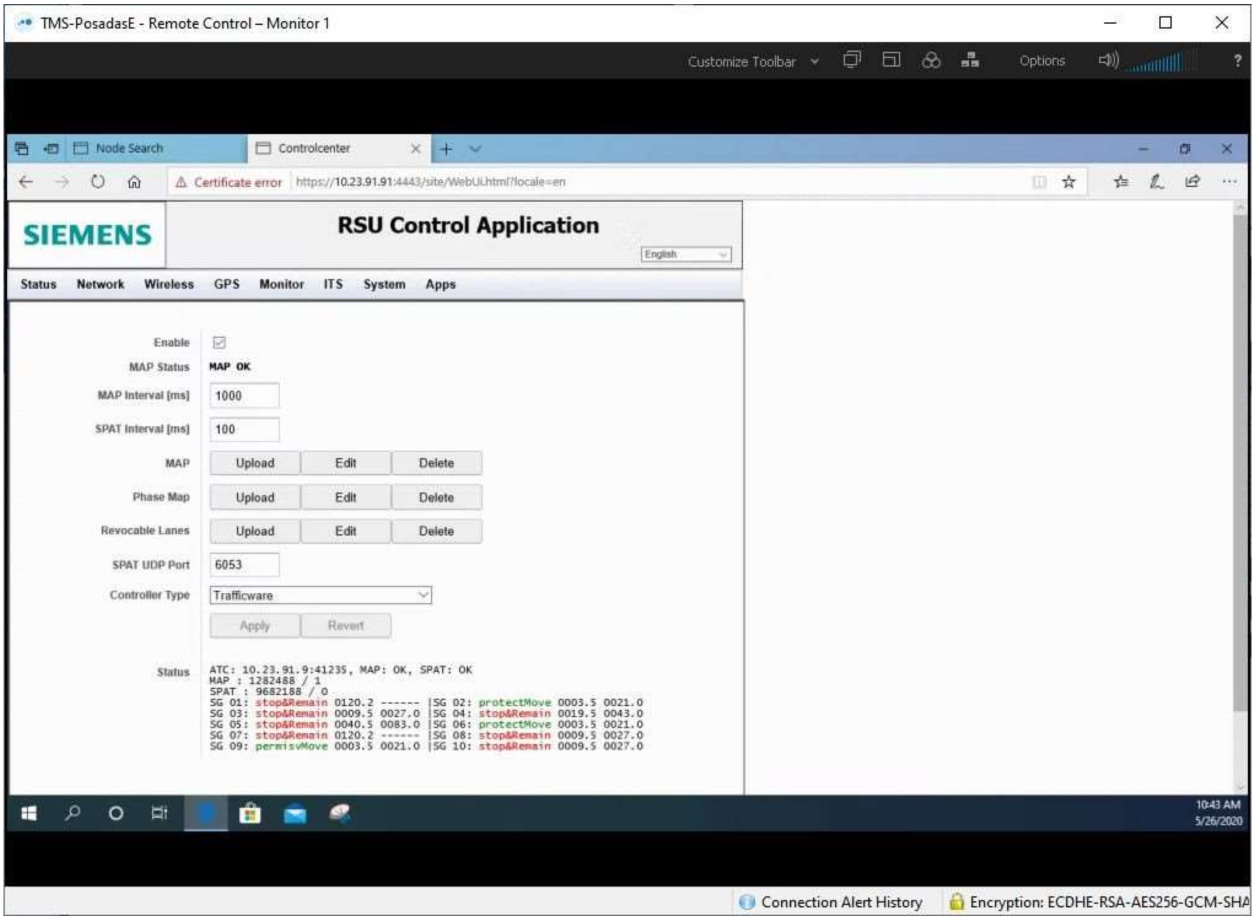

Figure 3-3. A snapshot of applications page for SPAT/MAP

Figure 3-3 show snapshot of the Apps->SPAT/MAP page. Here, we can monitor the ongoing signal phase and timing of the intersection via the RSU installed at that intersection. It is also on this page of the control panel that the MAP data may be edited for any change in the intersection geometry. We used this interface to edit the intersection IDs, making them compatible to those assigned by the City of Gainesville. The RSU itself includes internal data storage for intersection map geometry which may be updated seamlessly without need to replace controllers.

3.3 – Java Application to Receive Messages from RSUs

The Java message receiver used WebSocket to send subscription to, and receive message wave from, the RSUs. The receiver reads a script file with message sent on each line and custom control command. In the DSRC message collector, we send the subscription command and use the “!wait” command to let the WebSocket stay connected to receive the message wave from the RSU.

The Java receiver is forked by a Python program whenever there's no ongoing connection to the server. After a message is received, the message is written into the standard output, and this message is forwarded to a Python interpreter using the Python subprocess PIPE. The control message is also written to the standard output stream (stdout) so the Python interpreter can check whether the connection is alive or not.

The Python interpreter, upon receiving the messages, first extracts the byte-encoded XML message from the raw message wave and decodes it. The syntax and semantics of the XML message may be found in standard SAE J2735.

3.4 – Processing Messages Received from RSUs

The Python program parses the RSU messages, and for each message, it determines its type and extracts the most relevant fields of the message. Finally, the data are written to an AWS relational database, and the next message is processed similarly. We extract two of the most important <attribute, value> pairs for each message. The details of the message processing for each message type are given below. As of the time of writing this report, we receive five types of messages from the RSUs, which are BSM, PSM, SPAT, TIM, and MAP.

For repetitive messages, we store them just once over an interval. We set the interval size to be 5 minutes, and the message is stored in the database just once during that period. The interval has been implemented as a parameter and may be any value as required by the application. Examples of repetitive messages are MAP and TIM, for which the same message is received several times per second.

It should be noted that most of the messages contain a time stamp that is inserted by the RSU. This time stamp, in some cases (such as SPAT), has precision to a decisecond. When available, we store this timestamp along with the messages. For some messages, the time stamp specification is optional (such as for MAP), and in that case, we insert the current timestamp of the message processing device.

3.4.1 – MAP

The MAP messages contain information about the geometry of the intersection, which includes details of the ingress and egress lanes that make up an intersection and their signalGroup (or phasing) information for links made from a combination of ingress and egress lanes. The information about the intersection geometry is stored in each RSU by the traffic engineer, and this information is broadcast by the RSU as a MAP message. The signalGroup attributes used in SPAT messages refer back to the signalGroup definition in the MAP messages. For MAP messages, we store the attributes msgIssueRevision and layerType. The first attribute, msgIssueRevision, refers to a version of the message, and the second attribute, layerType, refers to the type of information contained in the message, which may be ‘intersectionData’, ‘curveData’, ‘roadwaySectionData’, and so on.

3.4.2 – SPAT

The Signal Phase and Timing messages (SPAT) store the signal status for each signalGroup along with the remaining times. These messages are also generated at a very high frequency (10 Hz approximately); however, only a few of these actually contain a change in signal status from the previous message. Thus, we store only those messages that contain information about the change of state of a signal and ignore the other messages that only contain repeating status of the signal. We also encode the signaling information in the message using a hexadecimal format.

It should be noted that we only process the downstream SPAT messages received from an intersection and ignore the upstream SPAT messages because they contain information about the neighboring intersections.

3.4.3 – BSM

The Basic Safety Messages (BSMs) are registered by any OBUs passing an intersection. The message structure from J2935 allows the RSU to capture various vehicle properties. For BSM, we store the attributes ID and speed of the vehicle. The ID is a temporary ID assigned to the vehicle, while speed is the speed of the vehicle while at the intersection. While there are other vehicle attributes, such as location, heading, and so on, for our message count application, these properties were not essential. Further, because count should reflect the number of unique vehicles passing the intersection at a given time, we register only the first unique BSM message, over a 5-minute interval. This interval may be set separately in the code. Thus, the count of BSMs for any time interval for an intersection may be used to approximate the number of OBUs at that intersection at the given time.

3.4.4 – CSR

The Common Safety Request (CSR) message is a vehicle-specific message like BSM. This message allows a vehicle with an OBU to unicast requests to other vehicles for information required for the safety applications that are currently running. Usually, the responding vehicles would add this information to the appropriate place in their BSM when they broadcast it.

3.4.5 – EVA

The Emergency Vehicle Alert message is used to broadcast warning messages to surrounding vehicles that an emergency vehicle (typically an incident responder of some type) is operating in the vicinity and that additional caution is required.

3.4.6 – ICA

The Intersection Collision Avoidance (ICA) message is usually broadcast to other DSRC devices in the area to warn about a potential collision with another vehicle that is likely to be entering an intersection without the right of way. The sender may be either a vehicle with OBU or another source, such as the infrastructure. If the source is an infrastructure component, we store this message. The two attributes we pick up for this message are msgCount and ID. The former is simply a count while the latter is the temporary ID of the sending device. We store just one instance of this message over an interval of 5 minutes, so that the count closely reflects the number of possible incidents that happened at an intersection.

3.4.7 – NMEA

According to SAE J2735, “The NMEA Corrections message is used to encapsulate NMEA 183 style differential corrections for GPS/GNSS radio navigation signals as defined by the NMEA (National Marine Electronics Association) committee in its Protocol 0183 standard. Here, in the work of the SAE DSRC Technical Committee, these messages are ‘wrapped’ for transport on the DSRC media, and then can be reconstructed back into the final expected formats defined by the NMEA standard and used directly by GNSS to increase the absolute and relative accuracy estimates produced.” For now, we store the rev and msg attributes (revision and message type, respectively) and their values for this message.

3.4.8 – PDM

According to SAE J2735, “The ProbeDataManagement message is used to control the type of data collected and sent by OBUs to the local RSU, taken at a defined snapshot event to define RSU coverage patterns such as the moment an OBU joins or becomes associated with an RSU and can send probe data.” We store the attribute sample, which identifies the vehicle. For this message, we don't store a second attribute currently, but that may change in the future as we have a better understanding of this message.

3.4.9 – PVD

The ProbeVehicleData (PVD) message is used to exchange status about a vehicle with another RSU or other DSRC devices to allow the collection of information about typical vehicle traveling behaviors along a segment of road during a snapshot event. After collecting information in snapshots, the probe vehicle will send the information to the RSU along with information about the point in time and space when the snapshot event occurred. The attributes we store for this message type are segNum for the probe segment number and probeID, which are identity data for the probe vehicle.

3.4.10 – RSA

The RoadSideAlert (RSA) messages are used to alert travelers about hazards on the road. We store the attributes msgCount and typeEvent for this message type. The msgCount is a simple count while the typeEvent describes the event type based on the ITIS list of events. The latter includes such events as “bridge icing ahead", "train coming", or "ambulances operating in the area”.

3.4.11 – RTCM

According to SAE J2735, “The RTCM Corrections message is used to encapsulate RTCM differential corrections for GPS and other radio navigation signals as defined by the RTCM (Radio Technical Commission For Maritime Services) special committee number 104 in its various standards. Here, in the work of DSRC, these messages are ‘wrapped’ for transport on the DSRC media, and then can be reconstructed back into the final expected formats defined by the RTCM standard and used directly by various positioning systems to increase the absolute and relative accuracy estimates produced.” We store the msgCount and rev attributes of this message. The former is a simple count, and the latter stores the RTCM revision.

3.4.12 – SRM

The Signal Request Message (SRM) is a message sent by a OBU to the RSU in a signalized intersection. It is very useful for requesting either a priority signal request or a preemption signal request, which depends on the way each request is set. According to SAE J2735, “Each request defines a path through the intersection which is desired in terms of lanes and approaches to be used. Each request can also contain the time of arrival and the expected duration of the service. Multiple requests to multiple intersections are supported. The requestor identifies itself in various ways (using methods supported by the RequestorDescription data frame), and its current speed, heading and location can be placed in this structure as well. The specific request for service is typically based on previously decoding and examining the list of lanes and approaches for that intersection (sent in MAP messages). The outcome of all of the pending requests to a signal can be found in the Signal Status Message (SSM), and may be reflected in the SPAT message contents if successful.” We store the sequenceNumber and the requestor::id attributes for this message. The sequenceNumber is a message count, and the requestor::id attribute gives the ID of the requestor.

3.4.13 – SSM

The Signal Status Message (SSM) is a message sent by an RSU in a signalized intersection to the requesting OBU. According to SAE J2735, this message “is used to relate the current status of the signal and the collection of pending or active preemption or priority requests acknowledged by the controller. It is also used to send information about preemption or priority requests which were denied. This in turn allows a dialog acknowledgment mechanism between any requester and the signal controller. The data contained in this message allows other users to determine their 'ranking' for any request they have made as well as to see the currently active events. When there have been no recently received requests for service messages, this message may not be sent. While the outcome of all pending requests to a signal can be found in the Signal Status Message, the current active event (if any) would be reflected in the SPAT message contents." Currently, we just store the message sequenceNumber attribute of the message. We can add a second attribute in the future after analyzing an actual SSM from a RSU.

3.4.14 – TIM

The TravelerInformationMessages (TIM) that are used to send advisory and road sign information to the travelers. These messages are generated very frequently as well (multiple times in a single second). For TIM, we store the attributes msgCount, and packetID. A combination of these attributes may be helpful in tracking the content of the message.

3.4.15 – PSM

The PersonalSafetyMessages (PSMs) are registered by DSRC-capable phones carried by pedestrians, bicyclists, skateboarders, etc. For these messages, we store the attributes basicType and ID. The basicType of an object may be pedestrian, bicyclist, or wheelchair, skateboard and so on, that describes the propulsion type used. The attribute ID is a temporary ID assigned to the user. Like BSM, we store only one message per unique combination of the two attributes over a period of 5 minutes since the count in that case shows the number of people who used the intersection.

3.5 – Cloud Database

We store the SPAT data along with the other DSRC messages received by the RSU in a MySQL database in the Amazon Web Services (AWS) RDS Service. The table to store SPAT and the other RSU messages stores two attributes per message.

Figure 3-4 shows an example query to the table to display the SPAT messages. The message ID for SPAT messages as assigned in SAE J2735 is 19. The first entry, 1122cc, encodes a condition where phases 4 and 8 are green, whereas phases 3 and 7 are yellow (permissive movement allowed), the rest of the phases are all red. The second entry registered almost immediately is 0033ff, which encodes a condition of yellow on phases 3, 4, 7, and 8 and red on phases 1, 2, 5, and 6. Similarly, Figure 3-5 and Figure 3-6 show respectively the tables storing intersections in Gainesville, FL, and the possible types of DSRC messages.

```
mysql> select * from DsrcMainTable where dsrcMsgID=19 and intersection_id=7359 limit 10;
```

intersection_id	timestamp	dsrcmsgID	attribute1	value1	attribute2	value2
7359	2020-05-24 18:43:49.548000	19	eventState	1122cc	revision	39
7359	2020-05-24 18:43:49.808000	19	eventState	0033cc	revision	41
7359	2020-05-24 18:43:53.206000	19	eventState	0000ff	revision	71
7359	2020-05-24 18:43:56.403000	19	eventState	840873	revision	99
7359	2020-05-24 18:44:04.396000	19	eventState	048873	revision	42
7359	2020-05-24 18:44:08.532000	19	eventState	0408f3	revision	79
7359	2020-05-24 18:44:10.493000	19	eventState	448833	revision	97
7359	2020-05-24 18:45:42.571000	19	eventState	00cc33	revision	18
7359	2020-05-24 18:45:46.705000	19	eventState	0000ff	revision	55
7359	2020-05-24 18:45:48.805000	19	eventState	2102dc	revision	73

10 rows in set (0.04 sec)

Figure 3-4. Table showing SPAT messages for intersection 7359. The first entry is '1122cc' which encodes a condition where phases 4 and 8 are green, whereas phases 3 and 7 are yellow (permissive movement allowed); the rest of the phases are red. The attribute2 is unimportant for SPAT messages.

```
mysql> select * from DsrcLatLong limit 10;
```

intersection_name	ip	intersection_id	latitude	longitude
SW 2nd Ave @ 13th St - FYA	10.[redacted]	5360	29.6502523325507	-82.3393195764231
SW 5th Ave/Inner Rd @ 13th St	10.[redacted]	5660	29.6473291784845	-82.3393261805068
SW 8th Ave @ 13th St - FYA	10.[redacted]	5960	29.6448944828607	-82.3393181808896
SW Archer Rd @ Newell Dr - FYA	10.[redacted]	7359	29.6397045628961	-82.3418188124768
SW Archer Rd @ 18th St - FYA	10.[redacted]	7357	29.6382287432322	-82.3460025921795
SW Archer Rd @ 23rd Dr - FYA	10.[redacted]	7353	29.6336693457120	-82.3587624232869
SW 2nd Ave @ 34th St	10.[redacted]	5350	29.6504017946502	-82.3723638055293
SW Archer Rd @ 34th St	10.[redacted]	7350	29.6269354535710	-82.3724968751956
Windmeadows Blvd @ 34th St - FYA	10.[redacted]	7250	29.6283746553919	-82.3725925377656
SW 20th Ave @ 34th St - FYA	10.[redacted]	7050	29.6342806512682	-82.3725326069981

10 rows in set (0.01 sec)

Figure 3-5. A table storing the details about the intersections

```
mysql> select * from DsrcMessageID limit 10;
```

id	name	acronym
18	mapData	MAP
19	signalPhaseAndTiming	SPAT
20	basicSafetyMessage	BSM
21	commonSafetyRequest	CSR
22	emergencyVehicleAler	EVA
23	intersectionCollisio	ICA
24	nmeaCorrections	NMEA
25	probeDataManagement	PDM
26	probeVehicleData	PVD
27	roadSideAlert	RSA

10 rows in set (0.00 sec)

Figure 3-6. A table storing the possible DSRC message types

3.6 – User Interface

A fully-fledged user interface (Figure 3-7) has been developed for this application, with which the user can query the number of messages received for the various message types over a particular time interval.

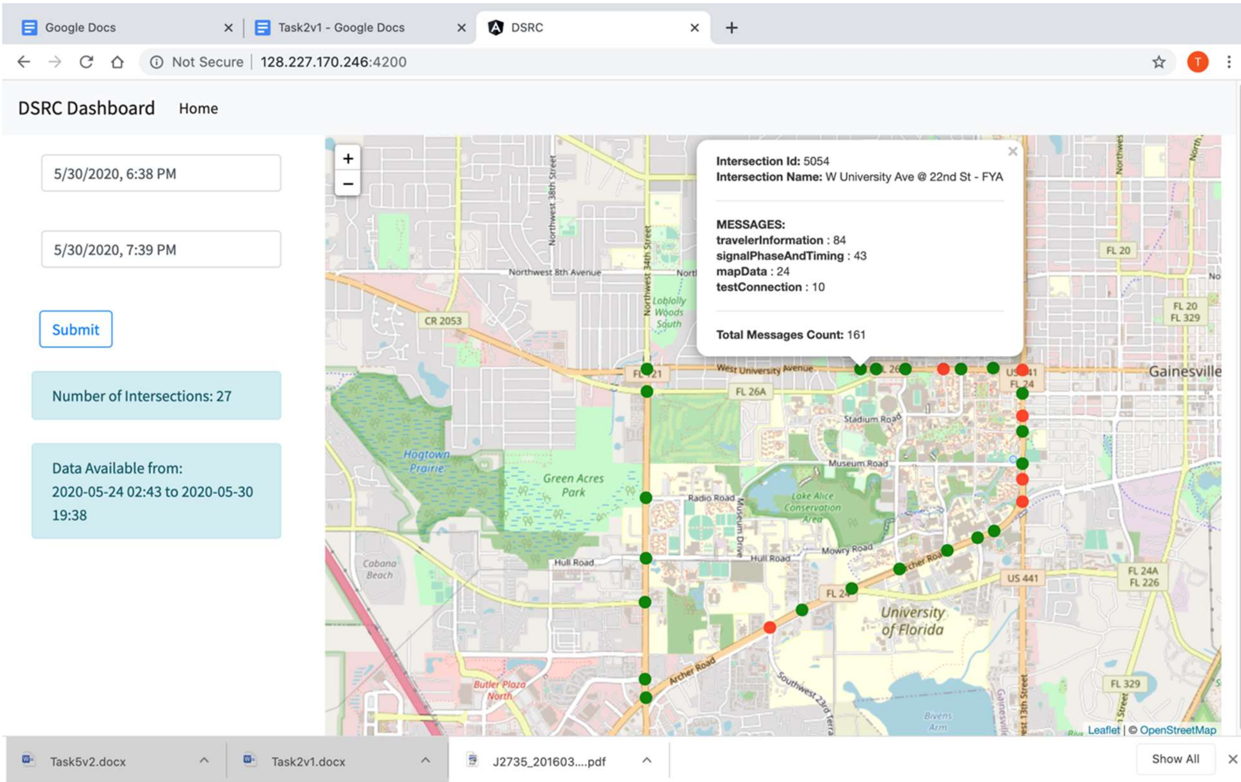

Figure 3-7. UI showing the intersections in Gainesville that have been fitted with RSUs and from which we can collect data as of May 30, 2020

3.7 – Comparison of Stored MAP Data versus Data Sent to OBUs

An appropriate mechanism was developed to test the relationship of stored MAP data and data sent to the OBUs. Initial tests were performed to ascertain accuracy in the data collection process.

3.8 – Deployment of CV Applications

In collaboration with Siemens, CoG, and FDOT, UF has tested the CV applications such as (1) Red Light Violation Warning, (2) Wrong Way Entry, (4) Curve Speed Warning, (5) Emergency Electronic Brake Lights, (6) Forward Collision Warning, (7) Intersection Movement Assist, (8) Work Zone Warning, (9) Do Not Pass Warning, (10) Speed Limit Warning, (11) Emergency Vehicle Preemption, (12) Wi-Fi/Bluetooth Travel Time Data, (13) Probe Enabled Traffic Monitoring/Virtual detectors, (14) Pedestrian to Vehicle Communication/Cyclist to Vehicle Communication, (15) Transit Signal Priority, (16) Pedestrian Collision Warning, and (17) Priority Green Light, during February 2020.

Further, a few of these applications have been accessible to OBUs for use by UF researchers and have been verified to function as expected. The CV applications are effective in making the driver more aware of the signal system (e.g., remaining red or green time), the speed limit of the lane segment upon egress at an intersection, an advance warning while entering a construction zone, and of course, several warnings for situations such as red light violation, wrong way entry, or too close to another OBU. It was observed that the red light violation is triggered even when entering an intersection on a yellow light. The flashing red warning on these events which are not illegal could be unsettling until a driver becomes accustomed to it. It is not clear whether making the driver accustomed to the warnings is effective because it tends to desensitize the driver and possibly make them ignore a potentially hazardous situation. This aspect of the driver interaction with the CV applications will be explored in-depth in a later task.

UF has also developed a SPAT application that captures only the required data from the SPAT messages sent by the RSUs, and the collected data is used in the sensor and video analytics applications.

3.9 – Conclusion

In this report, we described the development of software to collect the data streamed from RSUs. The software was deployed on a server at the City of Gainesville. The data collected are filtered for the top three important attributes for each message type, and these are stored in a table. Further, we developed visualization software that gives us an overall view of the various intersections with RSUs, and for each intersection, it gives basic statistics of the messages received from that RSU. We also described the CV applications that were deployed and an initial summary of driver reaction.

Chapter 4 – Data Analysis and Processing Software

In this chapter, we detail the progress and achieved objectives in our work with Siemens Mobility, Inc., and the City of Gainesville (CoG) to develop software for analyzing and processing data from the Gainesville Trapezium SPaT Project. Currently, Siemens Mobility, Inc., has furnished, installed, and integrated 27 roadside units (RSUs) at the 27 Trapezium signals. These RSUs were tested initially with six vehicles equipped with on-board units (OBUs) using dedicated short-range communication (DSRC), which enables highly secure, high speed, direct communication between vehicles and the surrounding infrastructure, without involving any cellular infrastructure.

As described previously, DSRC enables the transmission of data at high speeds (over one-way or two-way short-range to medium-range wireless channel), which is critical for communication-based active safety applications to prevent accidents. There are two types of DSRC: vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I). DSRC makes it possible to have a protected wireless interface constancy with short time delays and latency, while being highly robust under extreme weather conditions.

Specifically, we aim to collect, process, and analyze two important sources of data:

- Basic Safety Messages: These are broadcasted by vehicles to other vehicles and to infrastructure (RSUs). These contain speed and location data.
- Personal Safety Messages: These are broadcasted by pedestrians (and other vulnerable road users such as persons on motorized wheelchairs etc.) to nearby vehicles and infrastructure (RSUs).

In the rest of this chapter, we will describe our experience collecting these logs and developing the software to process the logs containing the above messages. We also present details on an automated system for Highway Capacity Software (HCS) evaluation of signalized intersections. We also make a note of the fact that the data collected and analyzed overlapped with the spread of COVID-19 pandemic flu (starting March 2020) and subsequent lockdowns and restrictions.

4.1 – Data Collection and Warehousing in Cloud Database

In Chapter 3, we described the data collection and storage in a cloud database. We store the various DSRC messages received by the RSU in a MySQL database in the Amazon Web Services (AWS) Relational Database Service (RDS). Messages from RSUs at 27 intersections are stored intersection-wise.

Figure 4-1 shows a few intersection details stored.

```
mysql> select * from DsrcLatLong limit 10;
```

intersection_name	ip	intersection_id	latitude	longitude
SW 2nd Ave @ 13th St - FYA	10.[redacted]	5360	29.6502523325507	-82.3393195764231
SW 5th Ave/Inner Rd @ 13th St	10.[redacted]	5660	29.6473291784845	-82.3393261805068
SW 8th Ave @ 13th St - FYA	10.[redacted]	5960	29.6448944828607	-82.3393181808896
SW Archer Rd @ Newell Dr - FYA	10.[redacted]	7359	29.6397045628961	-82.3418188124768
SW Archer Rd @ 18th St - FYA	10.[redacted]	7357	29.6382287432322	-82.3460025921795
SW Archer Rd @ 23rd Dr - FYA	10.[redacted]	7353	29.6336693457120	-82.3587624232869
SW 2nd Ave @ 34th St	10.[redacted]	5350	29.6504017946502	-82.3723638055293
SW Archer Rd @ 34th St	10.[redacted]	7350	29.6269354535710	-82.3724968751956
Windmeadows Blvd @ 34th St - FYA	10.[redacted]	7250	29.6283746553919	-82.3725925377656
SW 20th Ave @ 34th St - FYA	10.[redacted]	7050	29.6342806512682	-82.3725326069981

```
10 rows in set (0.01 sec)
```

Figure 4-1. A table storing the details about the intersections

For each intersection we store various message types. Figure 4-2 lists some of them along with the XML format of how those messages are stored.

```
mysql> select * from DsrcMessageID limit 10;
```

id	name	acronym
18	mapData	MAP
19	signalPhaseAndTiming	SPAT
20	basicSafetyMessage	BSM
21	commonSafetyRequest	CSR
22	emergencyVehicleAler	EVA
23	intersectionCollisio	ICA
24	nmeaCorrections	NMEA
25	probeDataManagement	PDM
26	probeVehicleData	PVD
27	roadSideAlert	RSA

```
10 rows in set (0.00 sec)
```

```
<currentMinute>2021-03-24_12:00:00</currentMinute>
.
.
<MessageFrame><messageId>20.....(BSM Message starts)
.
.
    <secMark>7150</secMark>
.
.
(BSM Message continues)
```

Figure 4-2. A table storing the possible DSRC message types (top). In addition to messages, the current minute is also stored to be used with secMark to ascertain the absolute time (bottom).

Additionally, we store the entire message payload as received in AWS S3 (Simple Storage Service). The received messages are in XML format and are collected in a file over a one-hour interval for each intersection. These files are then compressed using a Linux Gzip utility before shipping them to the cloud. In the interest of saving space, we store MAP and TIM messages once every five minutes, and only outgoing SPaT messages are stored when there is a change in signal color. We store all BSM and PSM messages. Further, BSM and PSM messages do not contain an explicit timestamp. Instead, they rely on a parameter secMark, which is defined in SAE J2735 as the number of milliseconds modulo 1 minute. Because we aggregate the received messages in a single file for a one-hour duration, the reference minute for each secMark cannot be easily determined. This problem is addressed by introducing additional XML messages that record the current local time. These messages are recorded before recording every BSM and PSM messages so that the secMark parameter in these messages may be resolved. An example of such an XML message recording the current time is “currentMinute” as shown in Figure 4-2. It contains the absolute wall-clock Eastern Standard Date-Time. It is generated at the start of a minute (In Figure 4-2, it is 12:00:00). The secMark parameter is the number of milliseconds after this currentMinute. In this example, this BSM was generated at 12:00:07.150, i.e., 7.150 seconds after 12:00:00.

Next, we describe various statistics pertaining to BSM and PSM messages, and these are of special interest to us. The processing was done using Python libraries, including Pandas for data analysis and Seaborn and Folium for plotting.

4.2 – Processing and Analyzing BSMs

The basic safety messages (BSMs) are registered by the OBUs passing an intersection. Only about 60 vehicles currently have OBUs installed, and it is difficult to associate BSMs to vehicles. Based on our communications with Siemens, this is due to privacy and security features built into DSRC messaging, which ensures that a vehicle cannot be uniquely identified beyond a couple of intersections, in many cases not even beyond one.

The message structure from SAE J2735 allows the RSU to capture various vehicle properties. For BSM, we store the attributes ID and speed of the vehicle. The ID is a temporary identifier assigned to the vehicle, while speed is the speed of the vehicle while at the intersection. While there are other vehicle attributes, such as location, heading, and so on, for our message count application, these properties were not initially stored. However, starting in March 2021, they were stored as well. In the plots below, we see the various trends for BSMs.

In Figure 4-3, we can see that the number of BSMs seen has remained largely stable, increasing in April 2021.

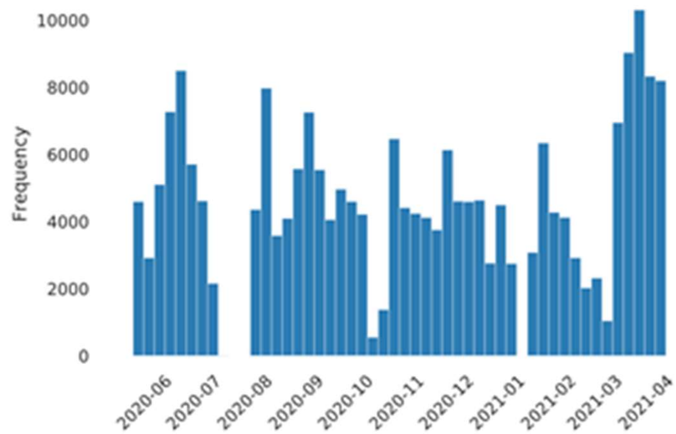

Figure 4-3. Number of BSMs over time, system-wide

However, the number of unique vehicle identifiers per day (Figure 4-4), when plotted, shows a sudden decline in November 2020 and significant increase in March 2021.

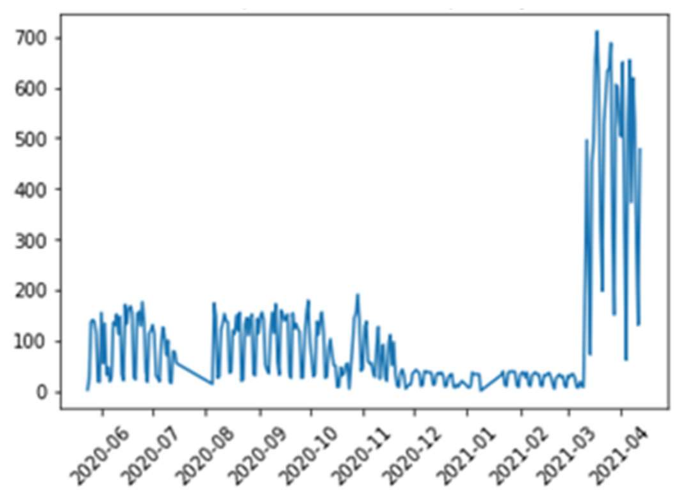

Figure 4-4. Number of unique vehicle identifiers over time, per day, system-wide

It is not possible to uniquely identify a vehicle to see which different identifiers a vehicle assumed as it moved within the Trapezium. Vehicle identifiers can change even from one intersection to the next within the same journey or can remain constant over a few intersections. Hence, the same vehicle may be assuming different identifiers as it moves through the system.

Figure 4-5 shows the average interaction (in seconds) a unique ID has with the system on a daily basis. The average interaction seconds is the number of seconds a unique identifier lasts. It could remain the same across multiple RSUs or change between RSUs. Vehicles usually start interacting (i.e., their BSM are collected by RSUs) when they are 120–160 ft (40–50 m) upstream of the intersection. BSMs are broadcasted at 10 Hz, hence 10 messages captured with a single unique ID would indicate 1 second of interaction time.

When we look at the average interaction of a vehicle identifier in seconds (Figure 4-5), we see it interacts much longer after November 2020.

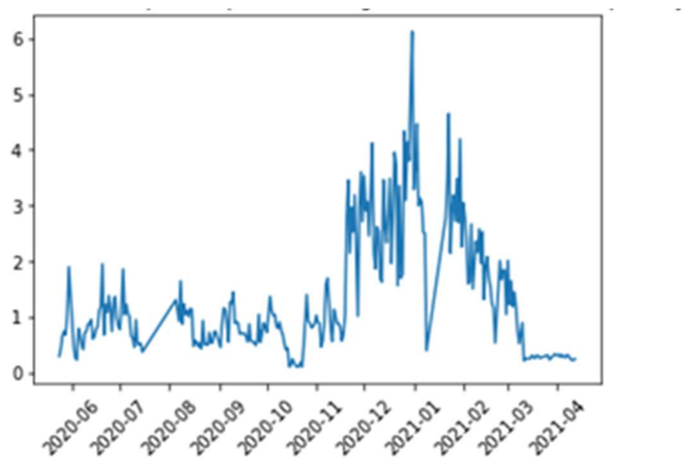

Figure 4-5. Average interaction of a vehicle identifier with RSU on a daily basis

Figure 4-6 shows the mean speed of the equipped vehicles (i.e., vehicles broadcasting BSM which are being captured by the Trapezium RSUs) over the days of the week. We can see that the mean speed of the equipped vehicles at various interactions is mostly constant, but slightly higher on the weekends, due to lower traffic.

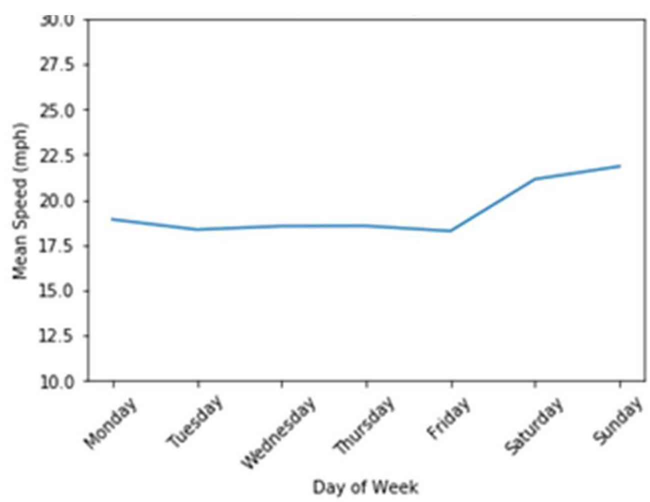

Figure 4-6. Mean speed of equipped vehicles over day of week

In Figure 4-7, we can see from the distribution of speeds that most of the time, a vehicle is travelling below 50 mph, with a peak between 10–20 mph.

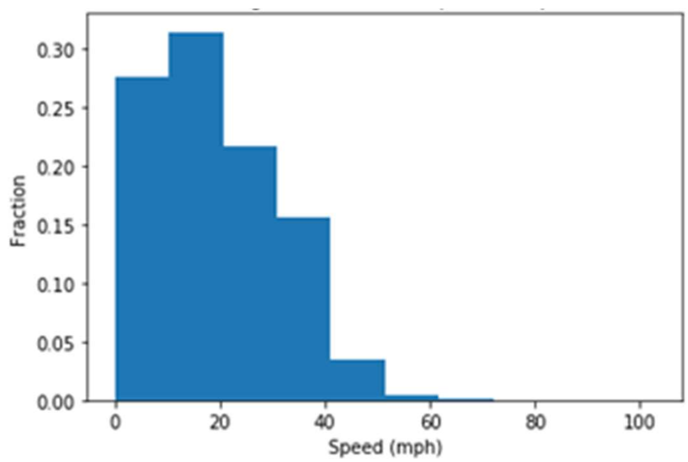

Figure 4-7. Distribution of equipped vehicle speeds

4.3 – Processing and Analyzing PSMs

The personal safety messages (PSMs) are registered by Wi-Fi–enabled mobile phones carried by pedestrians, cyclists, skateboarders, etc. For these messages, we store the attributes basicType and ID. The basicType of an object may be pedestrian, bicyclist, wheelchair, skateboard, and so on that describes the propulsion type used. The attribute ID is a temporary identifier assigned to the user. PSMs can be generated by users carrying a Wi-Fi–enabled phone, but when a regular pedestrian call is made at an intersection by a user just pressing the pedestrian button, such PSMs have 0 heading and static latitude-longitude (of the intersection location).

In the plot below (Figure 4-8), we see the trend for such non-Wi-Fi–enabled phone PSMs (i.e., regular pedestrian calls by pushing the button at the intersection). There is a general increase over time, likely due to relaxing COVID norms, leading to more business re-openings and corresponding pedestrian crossings.

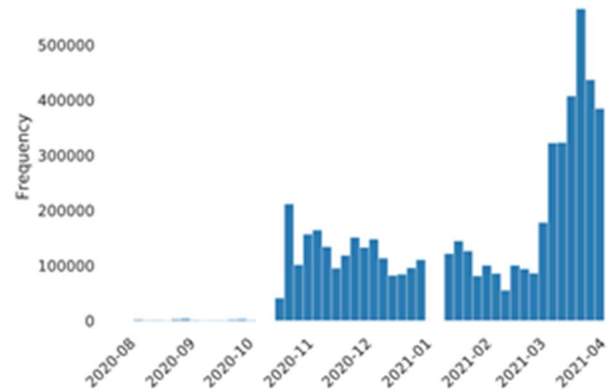

Figure 4-8. Number of PSMs over time via regular push-button ped calls, system-wide

For analyzing PSMs collected by Wi-Fi–enabled phones (i.e., not regular pedestrian calls), we conducted field experiments of the Siemens PedX app in the Gainesville Trapezium. The map in Figure 4-9 shows the intersections tested. Red crosses indicate that Trapezium Wi-Fi was not detected. Even at the locations where the Trapezium Wi-Fi was working, we were unable to connect to the Wi-Fi network, and thus no "PedX" phone app-based PSMs were generated.

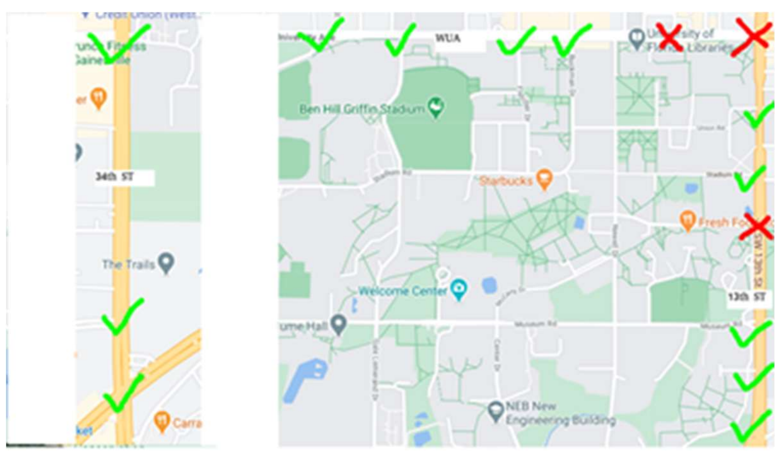

Figure 4-9. Test locations for PedX app: three intersections on 34th St and 12 intersections along 13th St turning left into W Univ. Ave. Green ticks show locations where Wi-Fi was detected, and red crosses indicate where it wasn't.

Phones used included a Google Pixel 4a and Motorola Moto X4 with latest Android 11, with PedX app successfully installed and interfacing with the GPS magnetometer as shown in the documentation. PedX app showed "Connecting" as expected and displayed user latitude and longitude, bearing, and speed using on-board GPS magnetometer as expected. The pedestrian movements (trajectories) during these field tests were recorded separately using a walking exercise app.

The current version of the app crashed within seconds of connecting to Trapezium Wi-Fi at all intersections. The app did not crash when Trapezium Wi-Fi was disabled or out of range, indicating that the app somehow interacted with the Trapezium Wi-Fi. We have informed Siemens regarding the issue with PedX app.

Correspondingly, in the RSU logs checked, no Wi-Fi–enabled phone PSM messages were seen at or near the time of crossing. These messages should have had non-zero heading and variable latitude and longitude. It can be concluded that PSMs from the PedX app were not received nor recorded by the RSUs.

4.4 – HCS Automation

In this section, we describe the methodology developed by the research team for automating the execution of HCS to generate intersection performance measures. For this automation implementation, "Intersection Control Delay" is extracted. However, the framework is general enough to extract other performance measures as well. Figure 4-10 shows the flowchart for executing HCS offline (for past dates and time). This software was developed for performing before-and-after studies as part of the next task, Task 4, and in general to automate the process for future initiatives.

Given the intersections, dates, and time intervals of interest, a Python script automatically downloads high-resolution controller logs containing raw detector data from Amazon Web Services (AWS) storage for the requested dates and times. Each analysis period is divided into 15-minute intervals. The same Python script then processes the detector activations from controller logs. With the help of detector channel mapping accomplished previously for each intersection, the script computes the turning movement counts (TMC) for the study approaches. After the end of this step, the process provides a set of TMCs for each approach and time interval and for the selected dates. The Python script then aggregates the counts by computing their averages for each intersection and each time interval and finally outputs these average counts in a comma-separated values (CSV) file. Next, a Windows PowerShell script processes the turning movement counts in the CSV file and generates an XML file that is used as input to HCS. Finally, the HCS runs in command-line mode, and a second Python script obtains the HCS output to extract the required information. The required information is the intersection delay for AM, PM, and off-peak periods for all subject intersections.

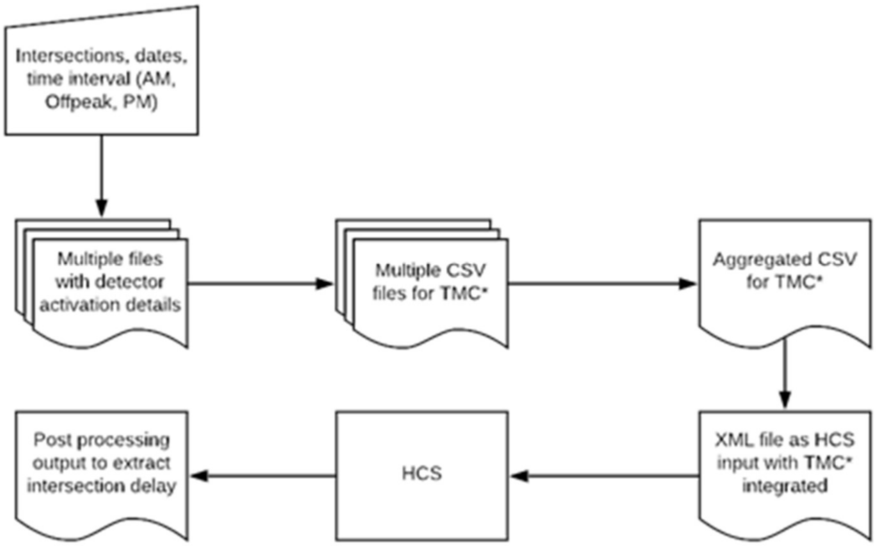

Figure 4-10. Flowchart showing the automation process (TMC = Turning Movement Count)

The presence of controller log files is crucial for this method. There is one controller log file for each intersection for each time period. The time period could be programmed by a traffic engineer with access to the controllers. This controller log file records the detector activation for all the detectors as ON or OFF (coded as 82 and 81, respectively). The automatic detector mapping involves advanced machine learning algorithms, as discussed in our paper "A Data Driven Approach to Derive Traffic Intersection Geography using High Resolution Controller Logs" (Mahajan et al., 2020). Manually mapping the detector channel involves using ATMS to observe the detector activations at an intersection and the video to observe where the vehicle is at the intersection. Our detector channel mapping code has been tested for the Trapezium intersections in Gainesville and for a few intersections in Orlando.

Next, we describe some of the challenges in setting up the automated flow as described above, and how the research team addressed those. A key component required for the flow to work is the detector channel mapping to the corresponding traffic phases. While this can be done manually by observing live video and corresponding detector and phase activations, Mahajan et al. (2020) developed an automated machine learning-based method to arrive at these mappings for different intersections. While using the detector channel mappings, we can directly count the detector activations and obtain the counts by approach, but there are some difficulties: handling missing or erroneous data, separating out through and right-turn vehicle counts for shared lanes, etc.

For this study, missing and erroneous data were reconciled in consultation with City of Gainesville staff. For right-turn and through shared lanes, we assumed that ratios of right-turn traffic to total lane traffic are consistent with previous projects, when such data were available. For locations without previously collected data, the research team collected a sample of turning movements using video from the traffic monitoring cameras.

Another key component of the workflow is the storage and access of the high-resolution controller logs containing detector activation data. We collect these data daily from all intersections equipped with the advanced traffic controllers (ATC) in the City of Gainesville. We use cloud storage to store these data for data scalability, availability, durability, and security. The data are stored in Amazon Simple Storage Service (Amazon S3), which is an object storage service offered by Amazon Web Services (AWS) for use in big data analytics. We use Python APIs in library boto3 to connect to this storage and download the files relevant to the flow based on input by the user.

Last but not the least, we describe two Python scripts and a PowerShell script that executes the steps in our automated workflow. These scripts are invoked in the right order by a parent Windows Batch file that iterates over all intersections and executes the workflow for AM, PM, and off-peak data.

An important HCS feature we used in this paper is its support for command line execution. This critical feature allowed us to automate the complete process. Regarding scalability of this automated method for delay computation, we need to study that separately, perhaps as a part of another project.

4.5 – Data Volumes

Data collected are stored on an Amazon Web Services S3 storage bucket. The bucket has been growing (Figure 4-11) since August 2020 and is now almost 12 GB in size. In June 2020 (when the highest rate in data growth was seen), the bucket grew at the rate of 100–150 MB daily, about 700–900 MB a week, and about 3.5 GB a month.

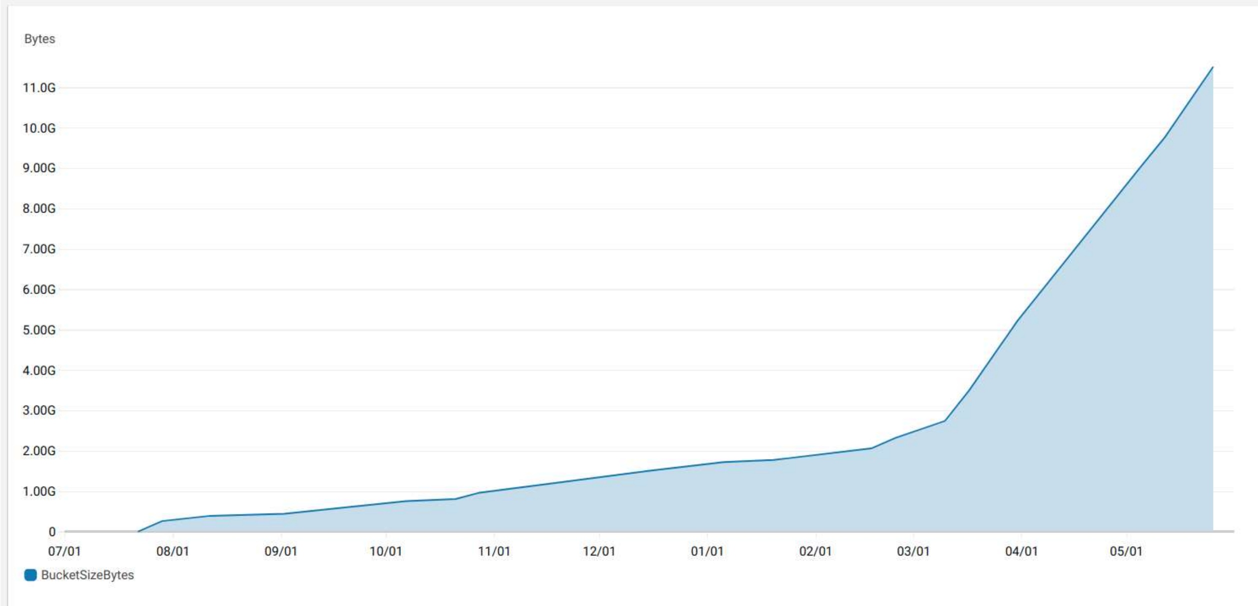

Figure 4-11. Graph of data volume being collected on Amazon Web Services storage bucket. The bucket size is presently 12 GB and is rising at the rate of 3.5 GB a month.

Assuming a similar growth rate, we can expect to use 50 GB of space per year, which can be easily provisioned on AWS S3, the current storage solution.

We do not intend to collect data beyond the scope of the project timelines. If these data are required by FDOT for further analysis, the data can be easily backed-up on online storage solutions like AWS S3, Dropbox, or Google Drive.

4.6 – Conclusion

As a part of Task 3, we developed software to analyze and process CV data obtained from the RSUs deployed at the Trapezium. Using this software, we can perform basic analytics on the BSMs. The fact that BSMs anonymize the vehicle identifiers is an impediment to developing more interesting and useful applications such as travel time through a corridor.

The data management plan developed by the team includes a data storage plan that is described in this report and consisted of (1) a relational database that stores important parts of the messages and is queried by the UI and (2) a short-term storage in an AWS S3 bucket for the entire messages. Eventually, the data in the short-term storage will be put in a long-term storage vault that will have a high latency for access time.

Chapter 5 – "Before" and "After" Data Collection

This section summarizes the work conducted under Task 4 ("Before" and "After" Data Collection). The first subsection summarizes the crash data analysis based on data from the Signal Four Analytics database. The second subsection describes the operational analysis results of seven signalized intersections. Detector data from CoG for each of the intersections are used to represent traffic demand in the traffic operational analysis. The third subsection presents the travel time and speed data trends obtained along the four major corridors of the Trapezium network. The fourth section summarizes OBU user experiences obtained through an interview.

5.1 – Crash Data Analysis

This section describes the safety analysis conducted using crash data along the four corridors of the Trapezium network (Figure 5-1) for six months before (June 1 to Dec. 1, 2019) and after (June 1 to Dec. 1, 2020) CV SPaT applications and the COVID pandemic. The analysis period is chosen to remove seasonal effects and have the same time period (six months) both before and after the SPaT deployments.

Section 5.1.1 provides an overview of the data obtained, followed by a summary of vehicular crashes, pedestrian crashes, and bicycle crashes year before and after the CV SPaT applications and the COVID pandemic.

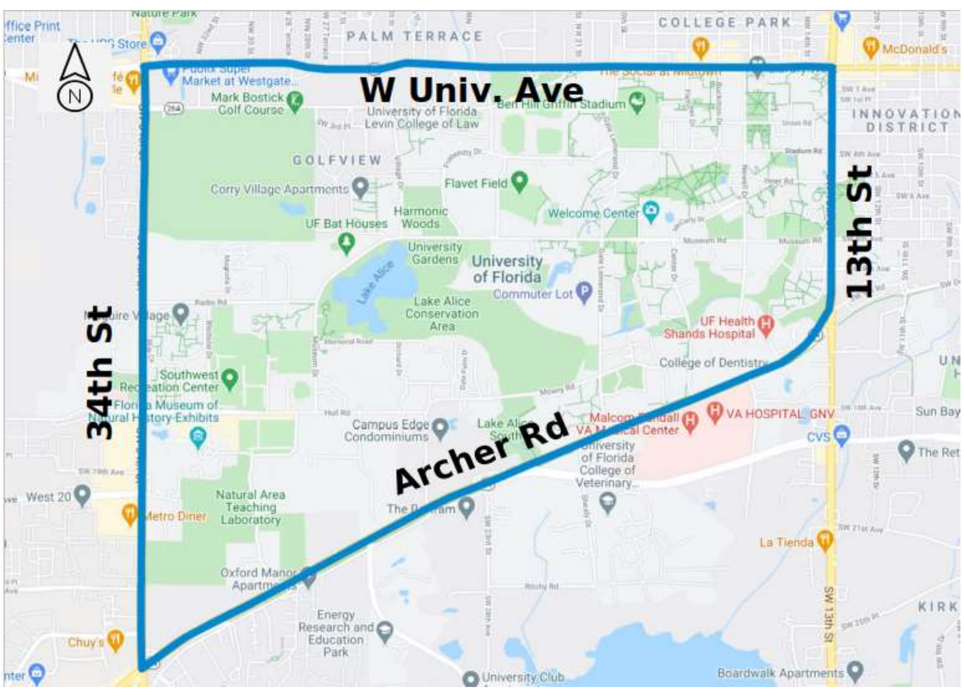

Figure 5-1. Study network consisting of four arterial corridors

5.1.1 – Crash Data Overview

Crash data were extracted from the Signal Four Analytics database, which is an inventory of crash reports filed by police officers.

Before the COVID pandemic, a total of 687 (1 fatal) vehicle crashes, 10 (0 fatal) pedestrian crashes, and 11 bicycle crashes (0 fatal) were recorded within the study area. A total of 494 (0 fatal) vehicle crashes, six (0 fatal) pedestrian crashes, and six bicycle crashes (0 fatal) were recorded after the COVID pandemic. Table 5-1 summarizes these crashes within the study network before and after CV SPaT applications and the COVID pandemic.

Table 5-1. Summary of crashes within the study network

Crash Type	Before (June to Dec. 2019)				After (June to Dec. 2020)			
	Total Crashes	Fatal	Incapaci-tating	Others	Total Crashes	Fatal	Incapaci-tating	Others
Vehicle	687	1	7	679	494	0	4	490
Pedestrian	10	0	0	10	6	0	0	6
Bicycle	11	0	0	11	6	0	0	6

Table 5-2 below shows the distribution of pedestrian, bicycle, and vehicle crashes by corridors within the study network before and after CV SPaT applications and COVID pandemic. The following can be observed:

- The highest frequency of vehicle crashes was observed along 34th St both before and after the COVID pandemic.
- Generally, the total number of crashes was lower after the COVID pandemic.
- The vehicle, pedestrian, and bicycle crash frequencies were significantly reduced after the COVID pandemic.
- The highest number of pedestrian crashes were recorded along W Univ. Ave before and after the COVID pandemic.
- The number of pedestrian crashes along W Univ. Ave were reduced by one.

Table 5-2. Total crashes by corridor

Crash Type	Before (June to Dec. 2019)				After (June to Dec. 2020)			
	13th St	34th St	Archer Rd	W Univ. Ave	13th St	34th St	Archer Rd	W Univ. Ave
Vehicle	118	219	165	185	88	164	126	116
Pedestrian	3	2	1	4	2	0	1	3
Bicycle	4	2	4	1	0	2	2	2

Table 5-3 shows the percent change of the traffic volumes and crashes along the corridors before and after CV SPaT applications and COVID pandemic. Generally, the percent change in crashes (24% to 36% reduction) was larger than the traffic volumes (4% to 17% reduction) in each of the corridors. This implies that crashes greatly reduced during the "after" period. Greatest reduction in both traffic volumes and total crashes happened on West University Ave.

Table 5-3 Percent change in daily traffic volume and crashes by corridor

	ADT[3]				**Crashes**			
	13th St	**34th St**	**Archer Rd**	**W Univ. Ave**	**13th St**	**34th St**	**Archer Rd**	**W Univ. Ave**
Before (2019)	13250	29513	35000	24175	125	223	170	190
After (2020)	12650	25681	29875	19975	90	166	129	121
% Change	**4.53**	**12.99**	**14.64**	**17.37**	**28**	**25.56**	**24.11**	**36.32**

5.1.2 – Vehicle Crashes

A total of 687 vehicle crashes occurred in the Trapezium network before the CV SPaT applications and a total of 494 vehicle crashes after the CV SPaT application along the Trapezium corridors. These include one fatality and seven incapacitating injuries before the CV SPaT applications and zero fatalities and four incapacitating injury crashes after the CV SPaT applications. Vehicle crashes consist of various types of collisions, including mopeds and motorcycles.

Table 5-4 shows the distribution of vehicle crashes by day of the week before and after the CV SPaT applications and COVID pandemic. Sundays have the lowest vehicle crashes before and after the COVID pandemic. Fridays had the highest number of crashes before the COVID pandemic, which decreased significantly after the pandemic. The higher number of crashes on Friday along W Univ. Ave was due to increased activity around restaurants and bars on the north side of the arterial. After the COVID pandemic, the activities were reduced due to COVID-related lockdowns where only a few businesses were operating.

[3] https://tdaappsprod.dot.state.fl.us/fto/

Table 5-4. Vehicle crashes by day of the week

Day of the Week	Before (June to Dec. 2019)					After (June to Dec. 2020)				
	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
Monday	17	24	28	17	86	15	26	27	18	86
Tuesday	17	26	30	30	103	13	32	19	20	84
Wednesday	19	31	19	20	89	14	21	22	15	72
Thursday	13	29	29	36	107	15	32	15	22	84
Friday	21	53	34	41	149	7	25	22	15	69
Saturday	19	35	15	31	100	13	18	11	15	57
Sunday	12	21	10	10	53	11	10	10	11	42

Table 5-5 provides the distribution of vehicle crashes by month of the year before and after the CV SPaT applications and COVID pandemic. Before and after the COVID pandemic, the month of June experienced the lowest number of crashes, most likely because of the university's summer break, during which there are limited student activities. September to November are the top three months in terms of total vehicle crashes in the network before and after the COVID pandemic. There is generally heavier traffic during these months due to football events. October is the peak month for football, including "homecoming" games. The higher number in September could be because new students are unfamiliar with the campus.

Table 5-5. Vehicle crashes by month of the year

Month of the Year	Before (June to Dec. 2019)					After (June to Dec. 2020)				
	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
June	13	36	15	22	86	13	20	11	16	60
July	23	33	32	35	123	5	23	18	14	60
August	21	30	28	28	107	15	17	22	16	70
September	19	36	32	38	125	22	36	30	23	111
October	24	46	23	31	124	16	33	17	18	84
November	18	38	35	31	122	17	35	28	29	109

Table 5-6 shows the distribution of vehicle crashes by time of day before and after the CV SPaT applications and COVID pandemic. Generally, vehicle crashes are higher during 3 PM to 6 PM than other times of the day. A higher number of crashes were experienced on 34th St both before and after the CV SPaT applications and the COVID pandemic. Before the COVID pandemic, the highest number of vehicle crashes occurred around 3 PM and 5 PM whereas after the pandemic, highest vehicle crashes were recorded around 4 PM.

Table 5-6. Vehicle crashes by time of day

Time of Day	Before (June to Dec. 2019)					After (June to Dec. 2020)				
	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
12:00 AM	2	4	4	1	11	0	3	2	4	9
1:00 AM	0	3	1	6	10	1	0	0	2	3
2:00 AM	2	1	0	2	5	1	0	0	0	1
3:00 AM	1	3	2	0	6	0	0	0	0	0
4:00 AM	1	0	0	2	3	2	1	1	1	5
5:00 AM	0	1	1	0	2	1	2	3	0	6
6:00 AM	2	2	6	5	15	0	3	1	0	4
7:00 AM	0	8	10	5	23	1	3	3	3	10
8:00 AM	6	4	9	4	23	2	5	5	3	15
9:00 AM	5	5	3	7	20	2	4	4	4	14
10:00 AM	6	2	3	4	15	1	7	7	2	17
11:00 AM	5	12	5	6	28	4	5	6	4	19
12:00 PM	12	12	17	15	56	9	16	14	4	43
1:00 PM	10	14	12	18	54	8	13	6	11	38
2:00 PM	13	20	12	14	59	11	9	9	14	43
3:00 PM	9	24	16	18	67	8	22	9	6	45
4:00 PM	12	20	18	12	62	9	20	13	20	62
5:00 PM	10	30	9	18	67	8	20	13	13	54
6:00 PM	7	13	8	9	37	3	13	9	6	31
7:00 PM	7	5	7	8	27	9	5	9	7	30
8:00 PM	2	13	7	9	31	2	7	3	2	14
9:00 PM	2	12	9	8	31	5	1	4	5	15
10:00 PM	1	8	3	8	20	1	1	2	4	8
11:00 PM	3	3	3	6	15	0	4	3	1	8

5.1.3 – Pedestrian Crashes

Table 5-7 shows the distribution of pedestrian crashes by day of the week before and after the COVID pandemic and CV SPaT applications. Before the COVID pandemic, the highest number of pedestrian crashes were recorded on Thursday and Saturday, whereas after the pandemic, the highest pedestrian crashes occurred on Thursday. No crashes were recorded on Monday before and after the pandemic.

Table 5-7. Pedestrian crashes by day of the week

Day of the Week	Before (June to Dec. 2019)					After (June to Dec. 2020)				
	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
Monday	0	0	0	0	0	0	0	0	0	0
Tuesday	0	0	1	0	1	0	0	0	0	0
Wednesday	0	0	0	1	1	0	0	0	0	0
Thursday	1	0	0	2	3	1	0	0	2	3
Friday	0	2	0	0	2	1	0	0	1	2
Saturday	2	0	0	1	3	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	1	0	1

Table 5-8 shows pedestrian crashes by month of the year before and after the COVID pandemic and CV SPaT applications. Before the pandemic, the highest pedestrian crashes were recorded in the month of July while the highest crash frequency was experienced in November after the pandemic. There were no crashes recorded in June (before the pandemic) and in October (after the pandemic). Given the short period considered for the safety analysis, the results may not be very instructive.

Table 5-8. Pedestrian crashes by month of the year

Month of the Year	Before (June to Dec. 2019)					After (June to Dec. 2020)				
	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
June	0	0	0	0	0	0	0	0	1	1
July	1	0	0	2	3	0	0	0	0	0
August	0	1	1	0	2	0	0	0	1	1
September	1	0	0	1	2	0	0	0	0	0
October	1	0	0	0	1	0	0	0	0	0
November	0	1	0	1	2	2	0	1	1	4

Table 5-9 shows the time-of-day distribution of pedestrian crashes before and after the CV SPaT applications and COVID pandemic. The late-night period from 11 PM–2 AM has more pedestrian crashes, especially along the W Univ. Ave corridor. Before the pandemic, the highest pedestrian crashes were recorded at 11 PM and 2 AM, while after the pandemic, the highest number of crashes was recorded at 12 PM. In contrast, the total vehicle crashes are the highest during the PM peak (4–6 PM) for this network.

Table 5-9. Pedestrian crashes by time of day

Time of Day	Before (June to Dec. 2019)					After (June to Dec. 2020)				
	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
12:00 AM	0	0	0	0	0		0	0	0	0
1:00 AM	0	0	0	1	1	0	0	0	0	0
2:00 AM	1	0		1	2	0	0	0	0	0
3:00 AM	1	0	0	0	1	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	1	0	1
5:00 AM	0	0	0	0	0	0	0	0	0	0
6:00 AM	0	0	0	1	1	0	0	0	0	0
7:00 AM	0	1	0	0	1	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0	0	0
9:00 AM	0	0	0	0	0	0	0	0	1	1
10:00 AM	0	0	0	0	0	0	0	0	0	0
11:00 AM	0	0	0	0	0	0	0	0	0	0
12:00 PM	0	0	0	0	0	1	0	0	1	2
1:00 PM	0	0	0	0	0	0	0	0	0	0
2:00 PM	0	0	0	0	0	1	0	0	0	1
3:00 PM	0	0	0	0	0	0	0	0	0	0
4:00 PM	0	1	0	0	1	0	0	0	0	0
5:00 PM	0	0	0	0	0	0	0	0	0	0
6:00 PM	0	0	0	0	0	0	0	0	0	0
7:00 PM	0	0	0	0	0	0	0	0	0	0
8:00 PM	0	0	0	0	0	0	0	0	0	0
9:00 PM	0	0	0	0	0	0	0	0	0	0
10:00 PM	0	0	1	0	1	0	0	0	1	1
11:00 PM	1	0	0	1	2	0	0	0	0	0

5.1.4 – Bicycle Crashes

Table 5-10 provides the distribution of bicycle crashes by day of the week before and after the COVID pandemic and CV SPaT applications. Before the pandemic, bicycle crashes are the highest on Tuesday, and after the pandemic the highest was on Monday. The number of bicycle crashes on the remaining weekdays are also higher than those recorded during weekends, likely due to higher bicycle activity during weekdays.

Table 5-10. Bicycle crashes by day of the week

Day of the Week	Before (June to Dec. 2019)					After (June to Dec. 2020)				
	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
Monday	1	0	0	1	2	0	1	1	2	4
Tuesday	1	2	2	0	5	0	0	0	0	0
Wednesday	1	0	0	0	1	0	0	0	0	0
Thursday	0	0	1	0	1	0	1	1	0	2
Friday	1	0	1	0	2	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0

Table 5-11 presents the distribution of bicycle crashes by month of the year before and after the CV SPaT applications and COVID pandemic. Generally, there were more bicycle crashes before the COVID pandemic, especially during the months of October and August. After the COVID pandemic, most classes were conducted virtually during the fall semester and only a few people used the campus, and this could be the reason for the fewer bicycle crashes after the COVID pandemic.

Table 5-11. Bicycle crashes by month of the year

Month of the Year	Before (June to Dec. 2019)					After (June to Dec. 2020)				
	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
June	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	1	1	0	2
August	0	0	1	0	1	0	0	0	0	0
September	1	0	1	0	2	0	0	0	0	0
October	2	1	1	0	4	0	0	0	0	0
November	1	1	1	1	4	0	1	1	2	4

Table 5-12 shows the number of bicycle crashes by hour of the day before and after the CV SPaT applications and COVID pandemic. After the COVID pandemic, most of the crashes occurred in the evening around 6 PM, and before the pandemic, it was at 10 AM.

Table 5-12. Bicycle crashes by time of the day

Time of Day	Before (June to Dec. 2019)					After (June to Dec. 2020)				
	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes	13th St	34th St	Archer Rd	W Univ. Ave	Total Crashes
12:00 AM	0	0	0	0	0	0	0	0	0	0
1:00 AM	0	0	0	0	0	0	0	0	0	0
2:00 AM	0	0	0	0	0	0	0	0	0	0
3:00 AM	0	0	0	0	0	0	0	0	0	0
4:00 AM	0	0	0	0	0	0	0	0	0	0
5:00 AM	0	0	0	0	0	0	0	0	0	0
6:00 AM	0	0	0	0	0	0	0	0	0	0
7:00 AM	0	0	0	0	0	0	0	0	0	0
8:00 AM	0	0	0	0	0	0	0	0	0	0
9:00 AM	1	0	0	0	1	0	0	0	0	0
10:00 AM	2	0	1	1	4	0	0	0	0	0
11:00 AM	0	0	1	0	1	0	0	0	0	0
12:00 PM	0	0	0	0	0	0	0	0	0	0
1:00 PM	0	0	0	0	0	0	0	0	0	0
2:00 PM	0	0	0	0	0	0	0	0	0	0
3:00 PM	0	0	0	0	0	0	0	0	0	0
4:00 PM	1	0	0	0	1	0	0	0	1	1
5:00 PM	0	0	0	0	0	0	0	0	0	0
6:00 PM	0	0	0	0	0	0	1	1	1	3
7:00 PM	0	1	1	0	2	0	0	0	0	0
8:00 PM	0	1	1	0	2	0	0	0	0	0
9:00 PM	0	0	0	0	0	0	0	0	0	0
10:00 PM	0	0	0	0	0	0	0	0	0	0
11:00 PM	0	0	0	0	0		1	1	0	2

The crash period considered for the analysis of before and after the CV SPaT applications was short due shorter "after" period. This was also influenced by the emergence of the COVID pandemic during the study period. Ideally, crash records over 2–3 years could provide better insights for comparison.

5.2 – Traffic Operational Analysis

Based on crash data, traffic flow, and pedestrian-bicyclist interactions, the research team selected seven signalized intersections to conduct traffic operational analysis before (January 25 to February 9, 2020) and after (the middle two weeks of the following months: April 2020, June 2020, October 2020, and February 2021). Four of these are located along W Univ. Ave, which has the highest number of pedestrian crashes within the study network. Two intersections are on the two corners of the Trapezium network along Archer Rd. The last intersection is 13th St at Museum Rd. (SW 8th Ave). The intersections with their IDs are given in Table 5-13, and they are shown in black circles in Figure 5-2.

Table 5-13. Selected signalized intersections with their ID

Intersection name	Intersection ID
W Univ. Ave at 34th St	S1
W Univ. Ave at 20th Terr (Gale Lemerand Dr)	S2
W Univ. Ave at 17th St	S3
W Univ. Ave at 13th St	S4
SW 8th Ave at 13th St	S5
SW Archer Rd at 13th St	S6
SW Archer Rd at 34th St	S7

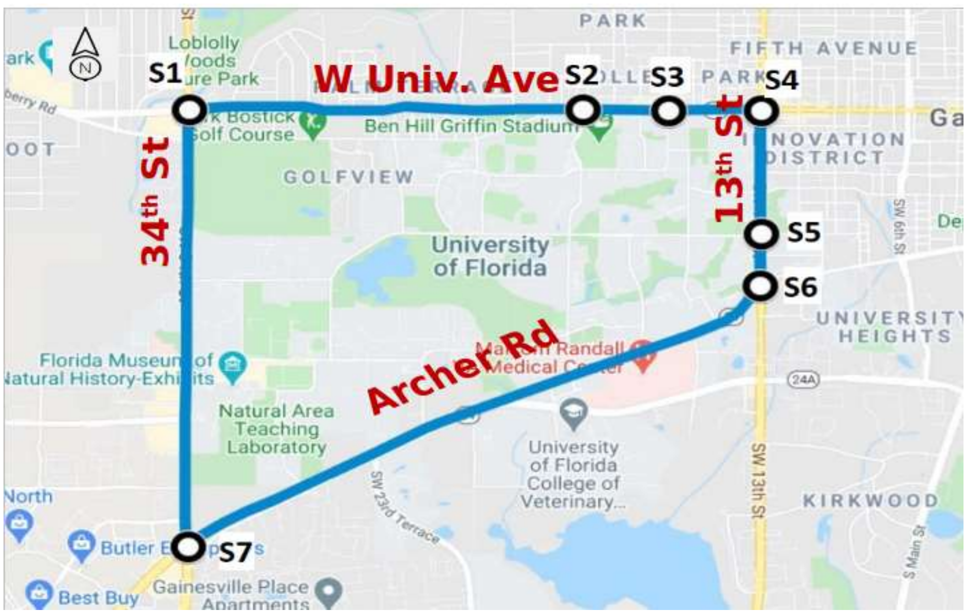

Figure 5-2. Traffic analysis intersections

The next subsection summarizes the data collected, followed by an overview of the traffic operational analysis results.

5.2.1 – Data Collection

To conduct operational analyses at the seven intersections, the research team obtained geometric data, traffic flow data, and signal timing data.

5.2.1.1 – Geometric Data

Geometric data were obtained using the aerial view from Google Maps. Table 5-14 shows an example of the information obtained for the intersection at W Univ. Ave and 13th St (Figure 5-3). All approaches have a left-turn-only lane, an exclusive through lane, and a shared through and right-turn lane. There is no on-street parking along any of the approaches. The approach grade is assumed to be 0% for all approaches.

Table 5-14. Geometric design information for W Univ. Ave and 13th St

Geometric Data	EB			WB			NB			SB		
	L	Th	R	L	Th	R	L	Th	R	L	Th	R
Number of lanes		4			3			3			3	
Average lane width (ft)		11			11			11			11	
Number of receiving lanes (ln)		2			2			2			2	
Turn bay length (ft)	450	999	240	240	999	—	310	999	—	470	999	—
Presence of on-street parking		0			0			0			0	
Approach grade (%)		0			0			0			0	
Total walkway width (ft)		10			10			10			10	
Crosswalk width (ft)		10			10			10			10	
Crosswalk length (ft)		70			70			75			70	
Corner radius (ft)		30			30			35			20	

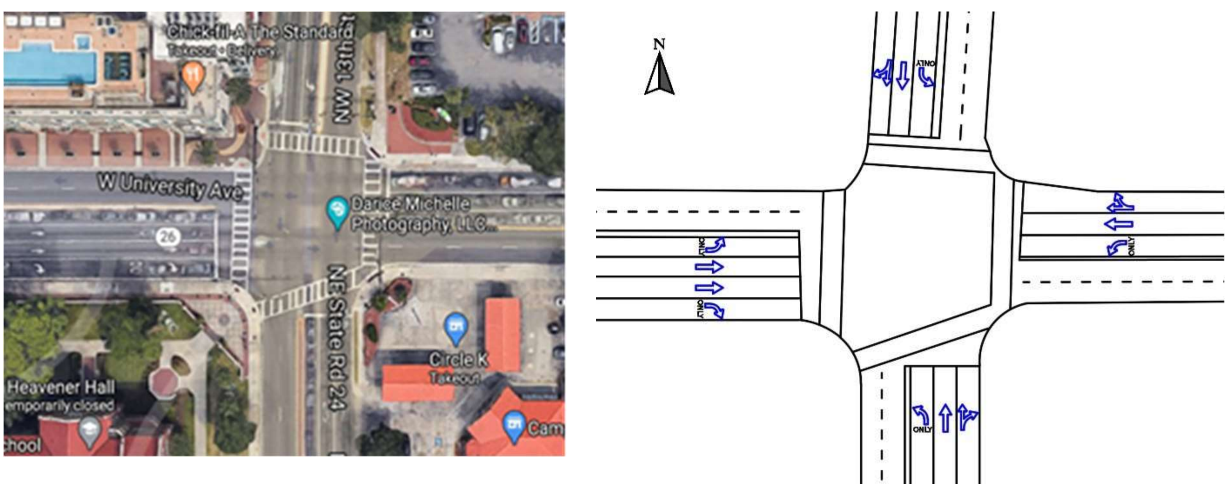

Figure 5-3. Layout and lane configuration of W Univ. Ave and 13th St

5.2.2 – Traffic Data

Traffic data were obtained using the City of Gainesville detectors. The research team mapped the detectors to the phases of the signalized intersections to obtain the respective turning movements.

Missing and erroneous data were reconciled in consultation with City of Gainesville staff. For right-turn and through shared lanes, we assumed ratios of right-turn traffic to total lane traffic consistent with previous projects, when available. For example, data from the ongoing project "Before-and-after study of Gainesville pedestrian-bicyclists connected vehicle pilot" were used to calculate the ratios of right-turn traffic to total traffic for intersection S4. The ratios for intersection S3 were estimated using turning movement data from the One-Way Pairs Study, conducted for CoG in 2019.

For locations without previously collected data, the research team collected a sample of turning movements using video from the Bosch traffic monitoring cameras. Data observed from the Bosch traffic camera at intersection S7 were used to estimate the ratios "right turn to lane total" for shared lanes at this intersection. S1 did not have any data from previous studies, and there were issues focusing the traffic camera on the approach of interest. Hence, the same "right turn to lane total" ratio was used for shared lanes in S1 as it was observed in S4 because both these intersections are on the same corridor with similar traffic patterns.

Data were collected during weekdays (Tuesday, Wednesday, and Thursday) for the period January 25 to February 9, 2020 (prior to the COVID pandemic) and the middle two weeks of the months April 2020, June 2020, October 2020, and February 2021 (post-COVID pandemic), for example, April 12–25, 2020. The research team collected data for the AM peak (7:30 AM to 8: 30 AM), off-peak (12 PM–1 PM) and PM peak (4:30 PM–5:30 PM) time periods. A total of sixty minutes (study period) of detector counts was extracted for all intersections at 15-min (analysis period) intervals for each of these three study periods.

The execution of Highway Capacity Software (HCS7) was automated to generate the performance measures of each intersection. Figure 5-4 below shows the flowchart for executing HCS offline (for past dates and time).

The steps of the process are as follows. Given the intersections, dates, and time intervals of interest, a Python script automatically downloads high-resolution controller logs containing raw detector data from Amazon Web Services (AWS) storage for the requested dates and times. Each analysis period is divided into 15-minute intervals. The same Python script then processes the detector activations from controller logs. With the help of detector channel mapping accomplished previously for each intersection, the script computes the turning movement counts (TMC) for the study approaches. After the end of this step, the process provides a set of TMCs for each approach and time interval and for the selected dates. The Python script then aggregates the counts by computing their averages for each intersection and each time interval and finally outputs these average counts in a comma-separated values (CSV) file. Next, a PowerShell script processes the turning movement counts in the CSV file and generates an XML file that is used as input to HCS. Finally, the HCS runs in command-line mode, and a second Python script obtains the HCS output to extract the required information. For this report, the required information is the intersection delay for AM, PM, and off-peak periods for all subject intersections.

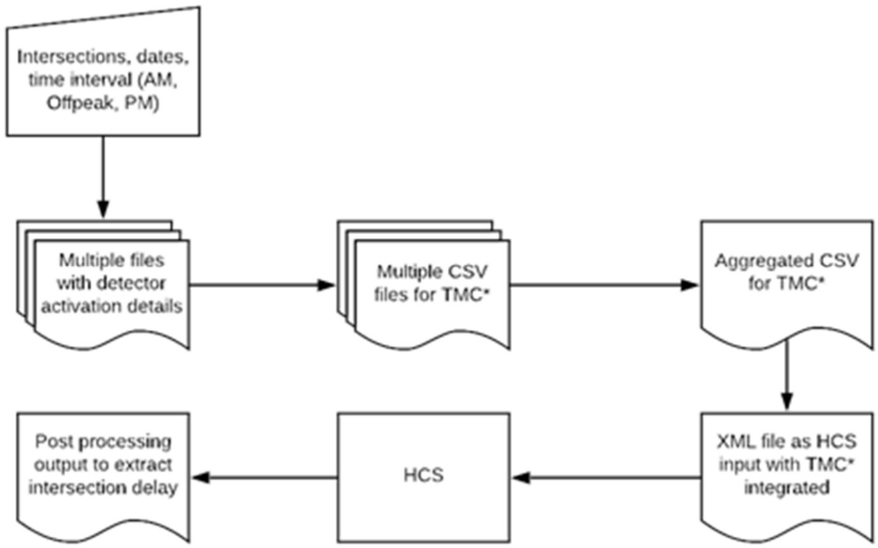

Figure 5-4. Flowchart showing the automation process (TMC= Turning Movement Counts)

5.2.3 – Signal Timing

Signal timing data are available from the CoG Advanced Traffic Management System (ATMS) database. For example, the signal timing data of W Univ. Ave and 13th St are shown in Table 5-15.

Table 5-15. Signal timing data for W Univ. Ave and 13th St

Phase Information	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Maximum Green (G_{max}) or Phase Split, s	25	45	25	45	30	70	25	55
Yellow Change Interval (Y), s	3.7	3.7	3.7	3.7	3.8	3.8	3.8	3.8
Red Clearance Interval (R_c), s	2	2	2	2	2	2	2	2
Minimum Green (G_{min}), s	7	12	7	12	7	12	7	12
Start-Up Lost Time (lt), s	2	2	2	2	2	2	2	2
Extension of Effective Green (e), s	2	2	2	2	2	2	2	2
Passage (PT), s	3	3.5	3	3.5	3	3.5	2.5	3.5
Recall Mode	Off	Off	Off	Off	Off	Off	Off	Off
Dual Entry	No	Yes	No	Yes	No	Yes	No	Yes
Walk (*Walk*), s	——	7	——	7	——	7	——	7
Pedestrian Clearance Time (PC), s	——	24	——	22	——	22	——	23

5.2.4 – Traffic Operational Analysis Results

The operational analysis for the signalized intersections was conducted using the HCS software through an automated process discussed above under traffic data. The analysis results for all seven intersections for the periods before and after CV SPaT applications and COVID pandemic are discussed below by corridor level. The graphs show the intersection delays, and the respective LOS are based on the HCM chapter 19.

5.2.4.1 – West University Avenue

Figure 5-5 below shows the delays at the four intersections located along the W Univ. Ave. before and after the CV SPaT applications and COVID pandemic.

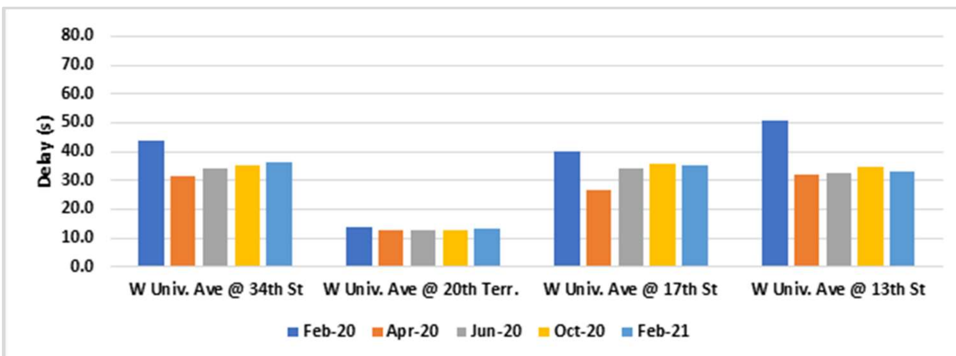

Figure 5-5. Intersection delays on W Univ. Ave

The following observations were made:

- Generally, all the intersections along W Univ. Ave experienced a drop in delay immediately after the COVID-related lockdowns, i.e., April 2020, and then recovered slowly.
- The W Univ. Ave at 20th Terr intersection has the lowest delay compared to the other intersections along the corridor. The intersection operated at LOS B both before and after CV SPaT applications and COVID pandemic.
- Before the COVID pandemic, W Univ. Ave at 13th St had the worst delay.
- The W Univ. Ave at 34th St intersection had an LOS D before the pandemic, which improved to LOS C after the pandemic during the months of April and June 2020 and recovered to LOS D in the months of October 2020 and February 2021.
- The W Univ. Ave 13th St intersection operated under an LOS D before the COVID pandemic and

at LOS C after the pandemic.

5.2.4.2 – 13th Street

The Figure 5-6 shows the delays at the three intersections located along 13th St. The W Univ. Ave at 13th St intersection is located at one of the corners of the trapezium corridor and thus found along the W Univ. Ave and the 13th St corridor.

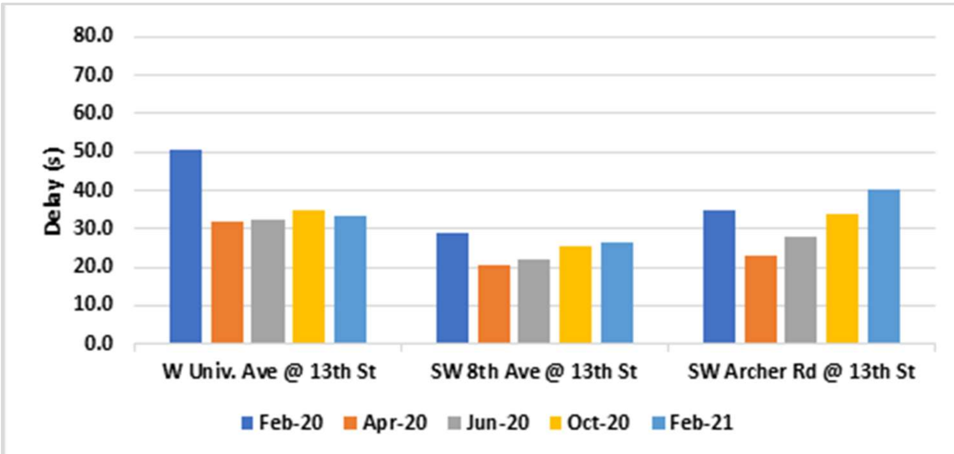

Figure 5-6. Intersection delays on 13th St

The following trends are observed:

- Like the intersections along the W Univ. Ave corridor, all the intersections along 13th St experienced a drop in delay immediately after the COVID-related lockdowns, i.e., April 2020, and then recovered slowly.
- Generally, the SW 8th Ave at 13th St intersection had the lowest delay compared to the other intersections along the corridor.
- Before the COVID pandemic, W Univ. Ave at 13th St had the worst delay (as seen along the W Univ. Ave corridor).
- The operations at SW 8th Ave at 13th St remained at LOS C before and after the CV SPaT applications and COVID pandemic.
- Traffic operated at LOS C at SW Archer Rd at 13th St before the pandemic and after the pandemic for the months of April, June, and October 2020, but the LOS worsened in February 2021 to LOS D.

5.2.4.3 – Archer Road

Figure 5-7 below shows the delays at the two intersections located along Archer Rd. SW Archer Rd at 13th St is a corner intersection found along the Archer Rd and the 13th St corridors.

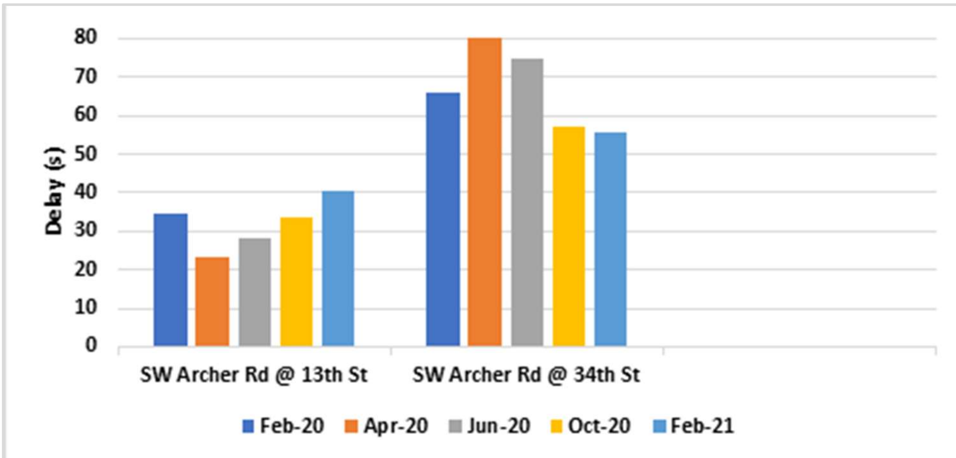

Figure 5-7. Intersection delays on Archer Rd

The following trends were observed:

- The intersection delay trends along the Archer Rd corridor are different from those observed along the W Univ. Ave and the 13th St corridors.
- At SW Archer Rd at 13th St, the intersection delay dropped in April, then recovered after the pandemic, with the month of February 2021 showing the highest delay.
- There was an increase in the intersection delay during the month of April 2020 at SW Archer Rd at 34th St, which was after the COVID-related lockdown. The delay is expected to have dropped since then because most students (larger population of Gainesville) had left for their hometowns. This could be due to several reasons. For instance, the intersection is located very close to a major shopping area (Butler Plaza), and due to the COVID pandemic, the working hours of many stores in this area were reduced, e.g., Walmart operated for 24 hours before the pandemic, then later the operating hours were from 7 AM to 8 PM. In turn, this could have led to increased demand for shopping. Also, during this time, due to the uncertainties of the length of time that the lockdowns would last, most people shopped more than usual to stock up their groceries.

5.2.4.4 – 34th Street

There are two selected intersections along 34th St, with the SW Archer Rd at 34th St intersection shared between the Archer Road and 34th St corridors. Figure 5-8 below shows the delay at these two intersections before and after the COVID pandemic.

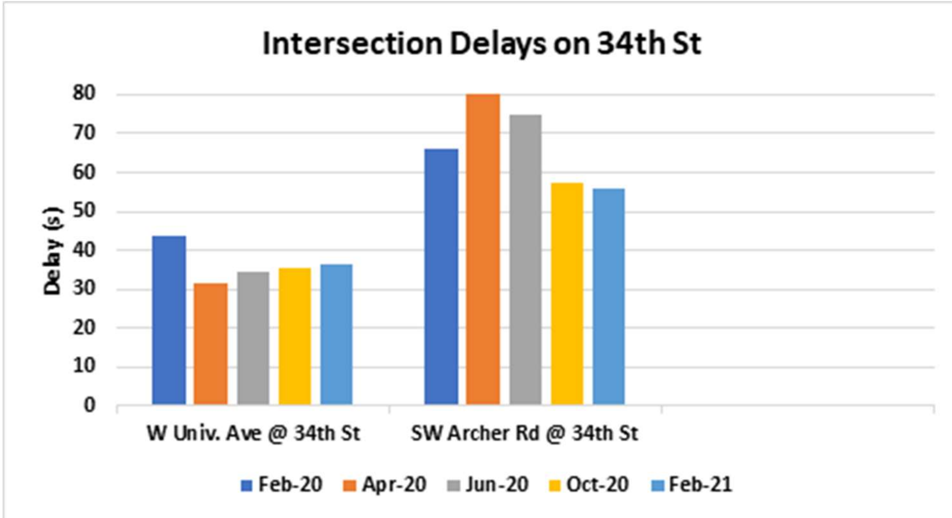

Figure 5-8. Intersection delays on 34th St

Trends observed:

- The trend observed along the 34th St corridor is similar to that of Archer Rd.
- At W Univ. Ave at 34th St, the intersection delay dropped in April, then recovered after the pandemic.
- SW Archer Rd at 34th St is as described in the Archer Rd corridor section.
- Compared to all other intersections along the corridors that have been discussed, SW Archer Rd at 34th St has the worst performance in terms of delays and LOS.

Generally, the two worst-performing intersections are W Univ. Ave at 13th St and Archer Rd at 34th Ave. Also, given that the flows used as input represent throughput rather than demand (which considers upstream queues), field conditions are likely worse than shown in the analysis results.

5.3 – Speed and Travel Time Analysis

Travel time and speed data along several corridors in Gainesville are available through the BlueARGUS dataset operated by TrafficCast International, Inc. This dataset provides speed and travel times for the four corridors of the Trapezium network. Data were obtained for the period January 25 to February 9, 2020, (prior to the COVID pandemic) and the middle two weeks of the months April 2020, June 2020, October 2020, and February 2021 (post-COVID pandemic), for example, April 12–25, 2020.

There are six sections along the Trapezium network for which BlueARGUS datasets are provided. These sections of the corridor are shown in Figure 5-9. Speeds along these sections of the corridors are discussed in this part of the report. Travel time data, graphs, and speed data (tables) are provided in Appendix B.

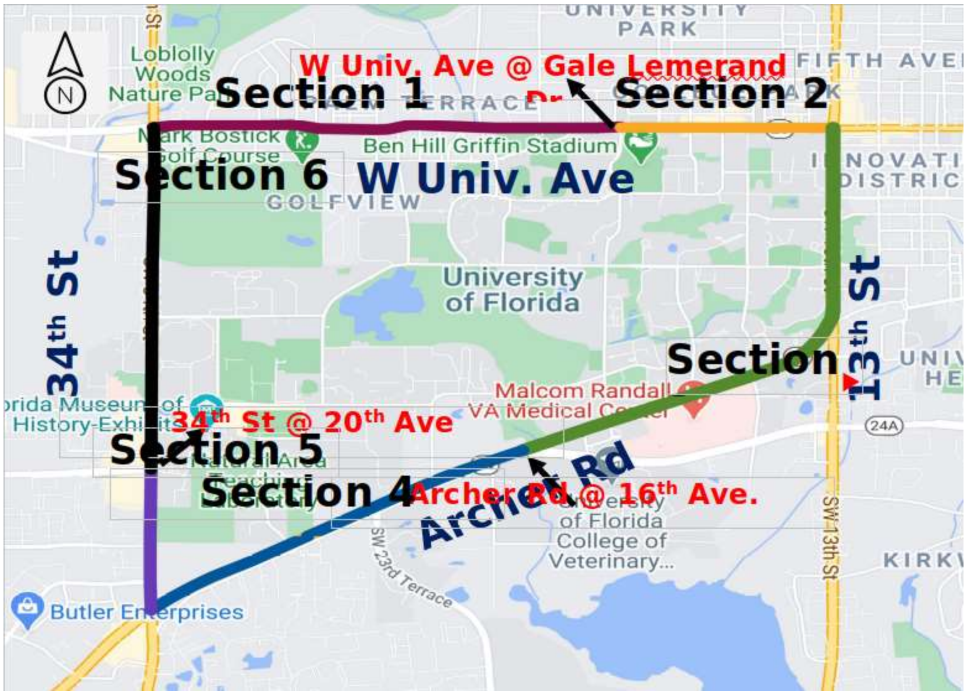

Figure 5-9. Speed data sections of the Trapezium network

5.3.1 – W Univ. Ave (West) – Section 1

W Univ. Ave forms the north border of the University of Florida campus. This section runs from 34th St to Gale Lemerand Dr and has a speed limit of 30 mph. The traffic volumes along this westerly section are usually lower than those along the easterly Section 2. The north side of this street is predominantly residential.

Figure 5-10 shows the comparison of the average speeds during weekdays (Tuesday, Wednesday, and Thursday), and Figure 5-11 shows the weekend (Saturday and Sunday) comparison along W Univ. Ave (West) for both the WB and EB directions. The figures shown are before and after CV SPaT applications. The before period was also a time when the University of Florida was fully operational, with students attending in-person classes before lockdowns due to the COVID pandemic, whereas the after period represents the time when there were COVID-related lockdowns.

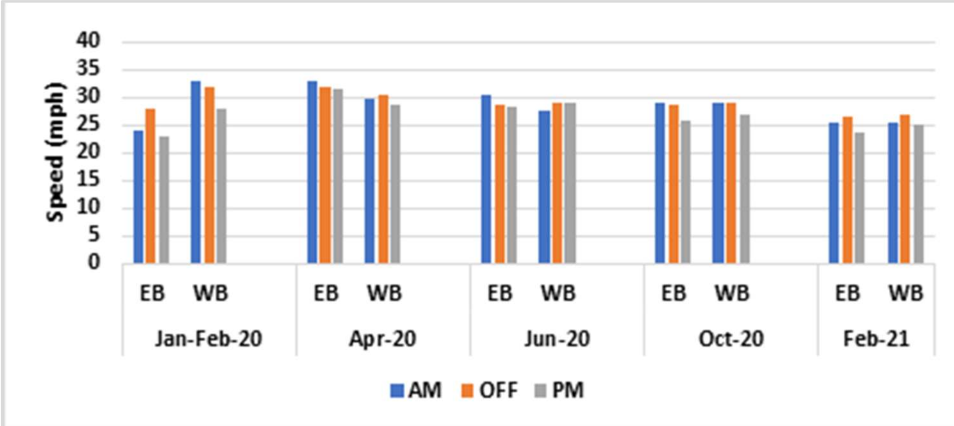

Figure 5-10. Section 1: Weekday speeds before and after CV SPaT deployment

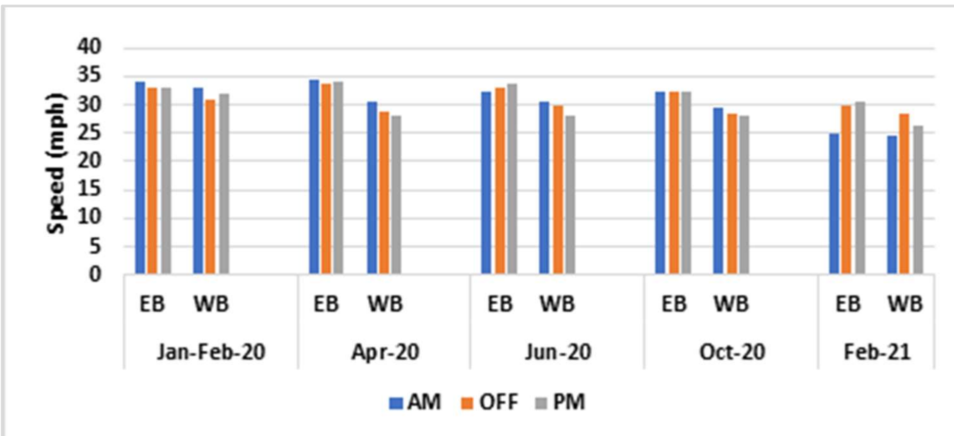

Figure 5-11. Section 1: Weekend speeds before and after CV SPaT deployment

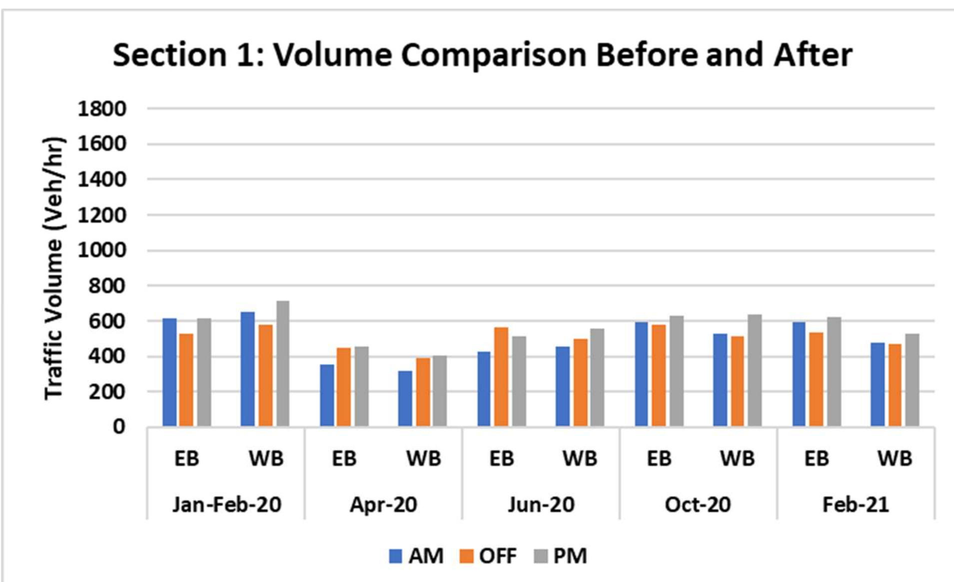

Figure 5-12. Section 1: Peak hour traffic volumes before and after CV SPaT deployment

The following trends were observed:

- In both before and after periods, the speeds are generally higher during the weekends than on weekdays in the EB and WB directions. However, in April, the WB speeds were higher during the weekday than on weekends. The WB direction leads to the Oaks Mall and other major shopping areas to the west of the university where high traffic is expected, but this was about the same time that UF was locked down and students returned to their hometowns due to the COVID pandemic, resulting in higher speeds.
- The weekdays AM and PM speeds in the EB were the lowest (below 25 mph) before CV applications and were generally over 25 mph after which corresponds to the high traffic volumes observed during those time periods.
- After the COVID pandemic, the weekend EB speeds slightly rose in the month of April and then constantly dropped for the months of June and October 2020 and February 2021.
- The weekend WB speeds were higher (above 30 mph) before CV applications and were generally lower after the deployment.
- The weekday speeds changed corresponding to change in traffic volumes. The traffic volumes dropped immediately after the COVID related lockdowns and later a recovery trend is observed.

5.3.2 – W Univ. Ave (East) – Section 2

The east W Univ. Ave section runs from Gale Lemerand Dr to 13th St (Section 2). There are several restaurants and bars along this section that are frequented by university staff and students. This section also serves as a popular nightlife spot. Jaywalking on W Univ. Ave is frequent, especially during the evening and night hours.

Figure 5-13 and Figure 5-14 below show the average speeds of the section before and after CV SPaT applications and COVID pandemic. Figure 5-13 provides average speeds during the weekdays (Tuesday, Wednesday, and Thursday), and Figure 5-14 shows the average speeds during the weekend (Saturday and Sunday).

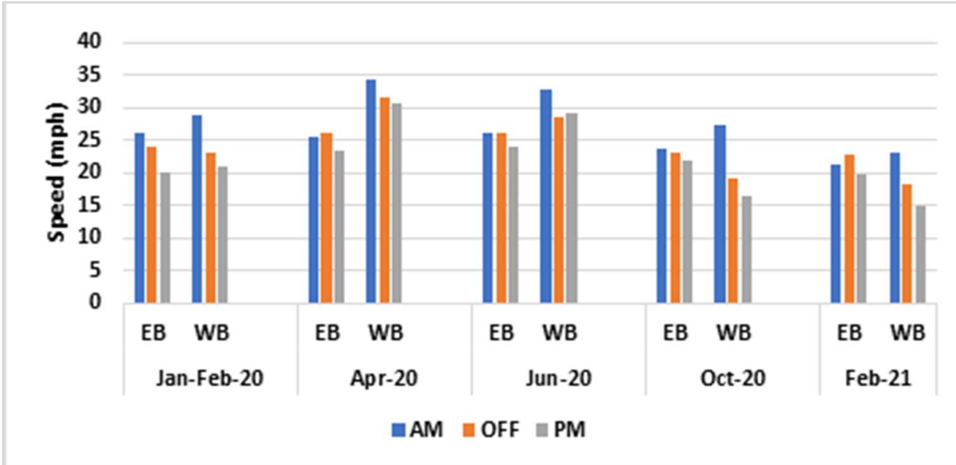

Figure 5-13. Section 2: Weekday speeds before and after CV SPaT deployment

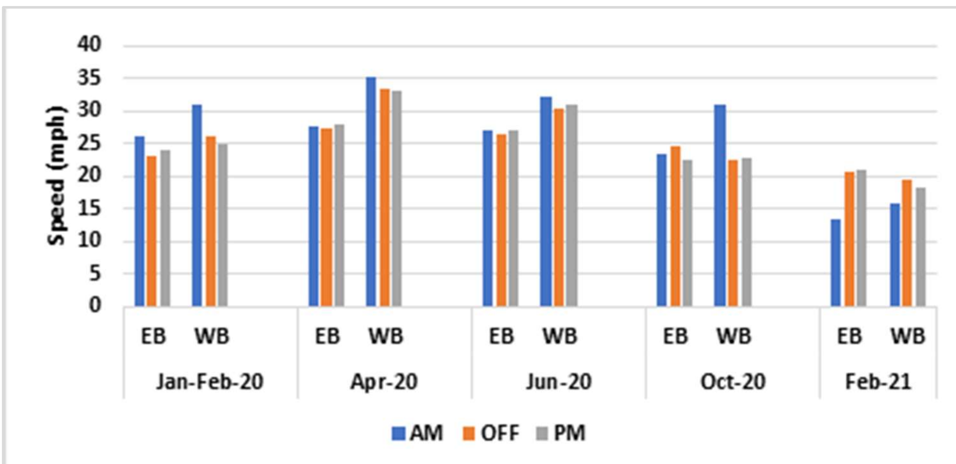

Figure 5-14. Section 2: Weekend speeds before and after CV SPaT deployment

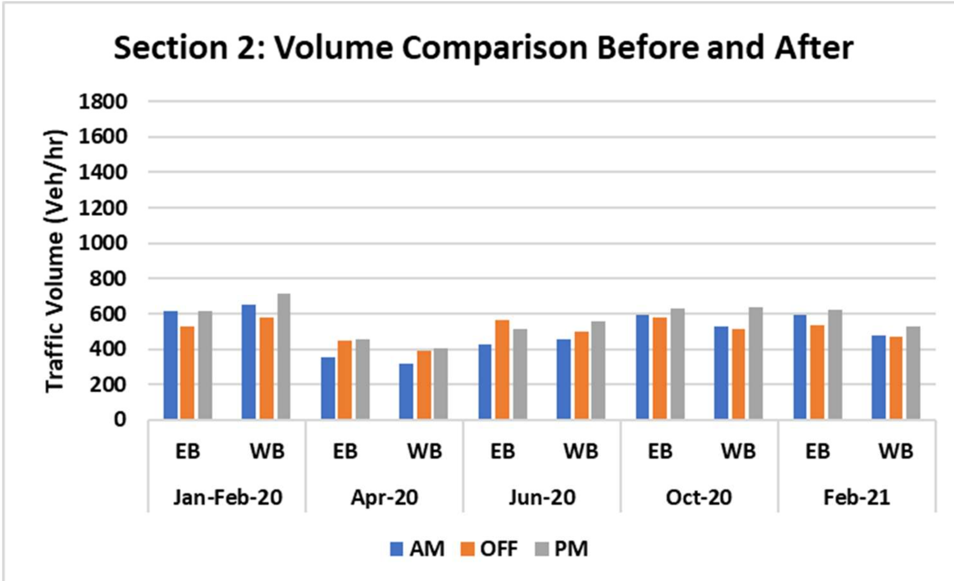

Figure 5-15. Section 2: Peak hour traffic volumes before and after CV SPaT deployment

The following were observed:

- Weekend speeds are generally higher compared to weekday speeds, apart from the month of February 2021. This could be due to the number of students returning to the university for studies and many activities slowly going back to normal with the social distancing compliance, i.e., dining in the restaurants, bars, etc.
- The WB direction has slightly higher average speeds during the weekdays AM, and the weekend AM periods.
- The weekday off-peak speeds are comparably lower throughout the given periods, apart from the month of June 2020 WB direction.
- The WB direction average speeds were the highest during the month of April (slightly above the speed limit of 30 mph) in the weekdays and the weekends. This was the period immediately after the COVID-related lockdown at the University of Florida when most students left the campus. This trend corresponds to the recorded traffic volumes where April has the lowest volumes. Generally, the traffic volumes were high before the COVID pandemic, dropped in April (immediately after the COVID related lockdowns) then later started to increase gradually.

5.3.3 – 13th St and Archer Rd (East) – Section 3

13th St is located along the east border of the UF main campus, which is part of the historic US-441 highway. There are several university buildings and facilities (Norman Hall, soccer field, parking, and sorority houses) as well as apartment complexes along this section.

Two important roadways within the university campus (Inner Road and Museum Road) intersect this section. These roadways are frequently used by students, who walk and bike to and from campus, especially during the daytime. The pedestrian-bicyclist tunnel under 13th St helps connect the two areas and reduces jaywalking in its vicinity.

Figure 5-16 and Figure 5-17 show the weekdays (Tuesday, Wednesday and Thursday) and weekend average speeds for the section 13th St and Archer Rd (east). Due to lack of Bluetooth travel time stations matching the exact coordinates of the 13th St, the section from Archer Rd at 16th Ave to W Univ. Ave at 13th St was used. Both directions were analyzed:

- NE bound (Archer Rd at 16th Ave to W Univ. Ave at 13th St)
- SW bound (W Univ. Ave at 13th St to Archer Rd at 16th Ave)

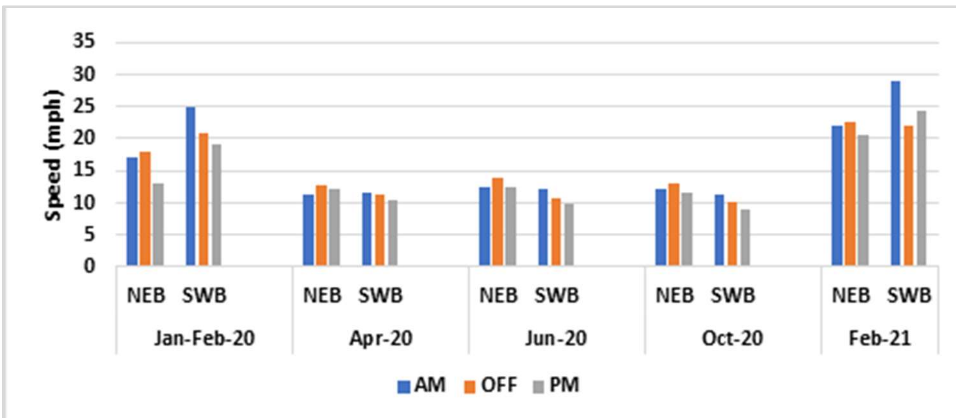

Figure 5-16. Section 3: Weekday speeds before and after CV SPaT deployment

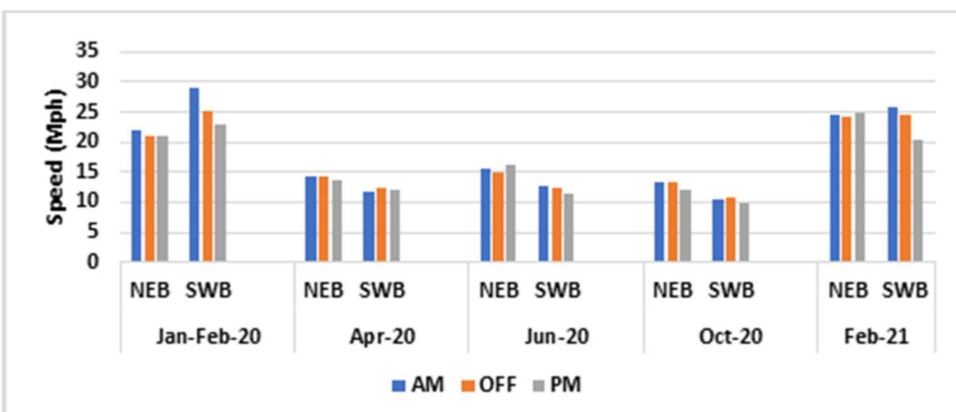

Figure 5-17. Section 3: Weekend speeds before and after CV SPaT deployment

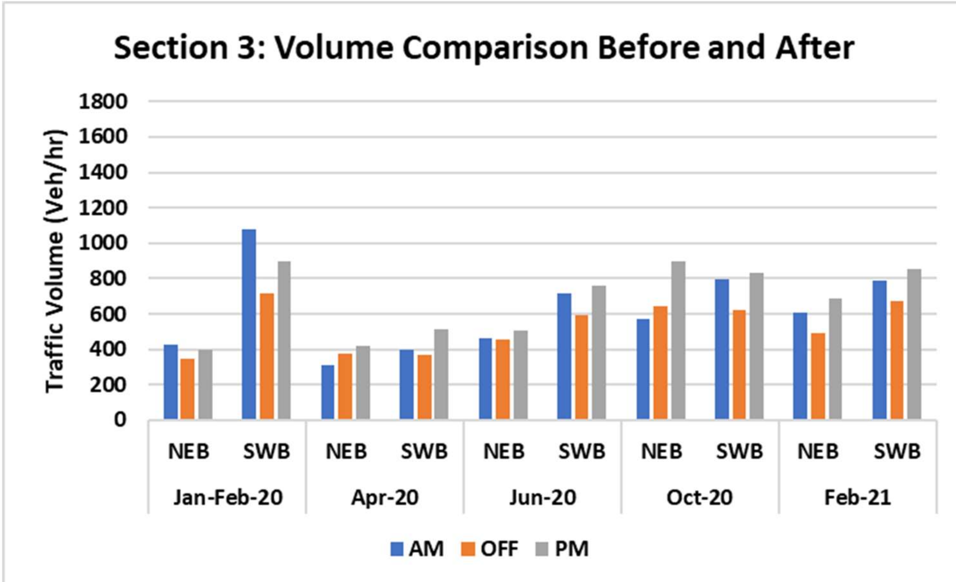

Figure 5-18. Section 3: Peak hour traffic volumes before and after CV SPaT deployment

The following trends were observed:

- Generally, the NEB and SWB direction average speeds were below the speed limit throughout the entire period, and the weekend speeds were slightly higher compared to the weekday speeds.
- The average speeds were higher before the COVID pandemic (Jan.–Feb. 2020), dropped after the COVID-related lockdowns, then rose in February 2021.
- The traffic volume dropped after the COVID related lockdowns and gradually increased thereafter.

5.3.4 – Archer Rd (West) – Section 4

Archer Rd is situated on the south border of the UF campus. There are several university buildings, including UF Health Shands (next to 13th St) on the east part of the road. There are several housing complexes around the road, along with Butler Plaza's retail stores, dining, and entertainment. Archer Rd intersects with I-75 a few miles southwest of the UF campus. This roadway provides access to the university and connects I-75 to downtown Gainesville. The speed limit along this section is 40 mph.

Figure 5-19 and Figure 5-20 provide the average speeds for this section during weekdays (Tuesday, Wednesday and Thursday) and weekend (Saturday and Sunday).

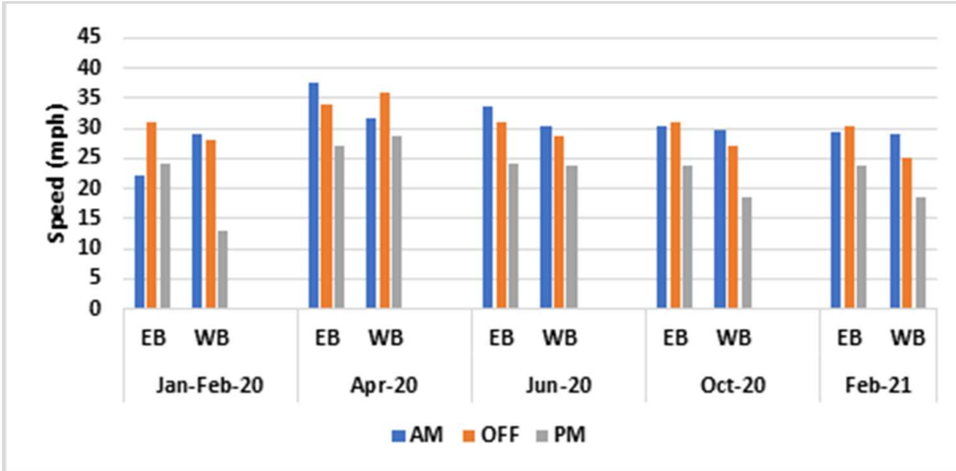

Figure 5-19. Section 4: Weekday speeds before and after CV SPaT deployment

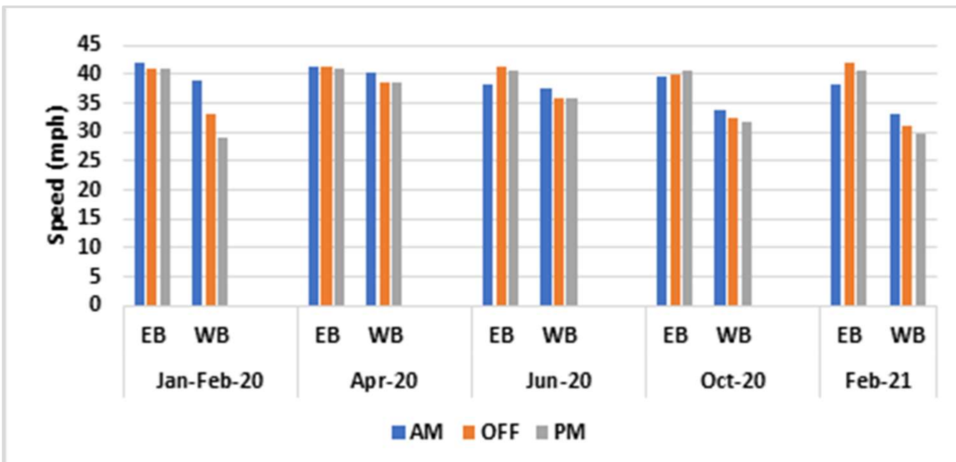

Figure 5-20. Section 4: Weekend speeds before and after CV SPaT deployment

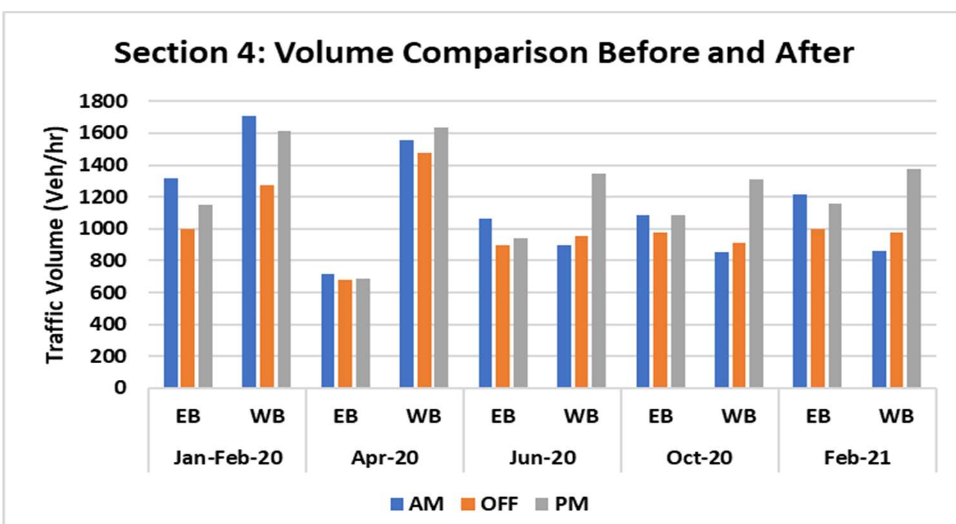

Figure 5-21. Section 4: Peak hour traffic volumes before and after CV SPaT deployment

The following were observed:

- The average speeds are lower on weekdays than on weekends in both EB and WB directions. The weekend average speeds remain relatively high before and after the COVID pandemic. The weekend EB direction speeds during the AM, off-peak, and PM hours are very close to the speed limit (range 38–42 mph). There are no recreational facilities or attractions along this section, and thus it is not used very much during the weekends.
- The PM peak has lower average speeds in both directions during the weekdays, which corresponds to the observed traffic volume trend.
- During the weekdays, the AM peak average speed was lower before COVID and improved afterwards due to the COVID-related lockdowns that reduced the volume of vehicles on the road.

5.3.5 – 34th St (South) – Section 5

The south section of 34th St (Section 5) is along the western border of the UF campus, between Archer Rd and SW 20th Ave. The speed limit on this arterial is 45 mph. There are several restaurants and stores along this section. The traffic volume along this section is the highest among all sections of the Trapezium network. Figure 5-22 and Figure 5-23 show the average speeds along the section for weekdays (Tuesday, Wednesday, and Thursday) and weekends. The following were observed:

- The AM peak average speeds are higher than the off-peak and PM peak during the weekdays and weekend for the selected period.
- The average speeds along this section are significantly below the speed limit along both directions for weekdays and weekend. This is likely due to heavy traffic at the Windmeadows Blvd and 34th St intersection, which carries significant amounts of traffic to Butler Plaza.
- The speeds are slightly higher during the weekend than on weekdays for both directions.
- Operations during the PM peak are lower throughout (particularly in the SB direction). This is due to traffic departing UF to access I-75 and suburban areas around Gainesville. This can be seen in the traffic volumes recorded are higher during the PM peak in the SB direction.
- The traffic volumes follow a trend where the volumes are relatively high before the pandemic, then drops due COVID related Lockdowns and gradually recover afterwards.

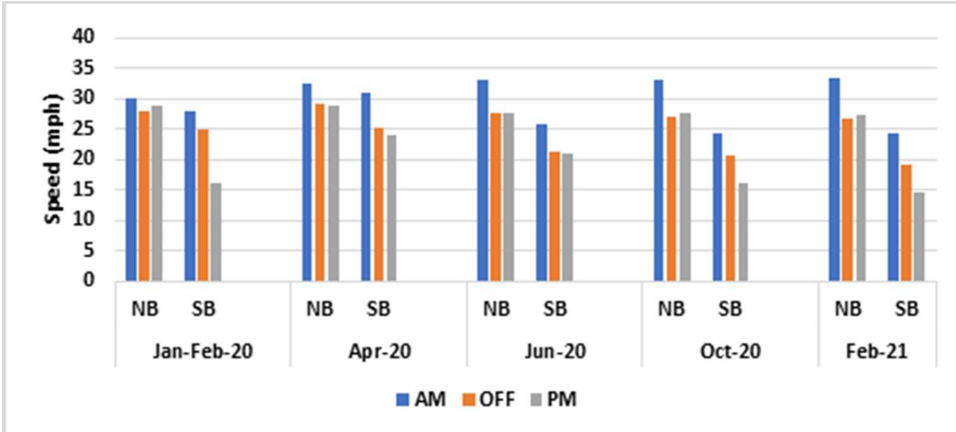

Figure 5-22. Section 5: Weekday speeds before and after CV SPaT deployment

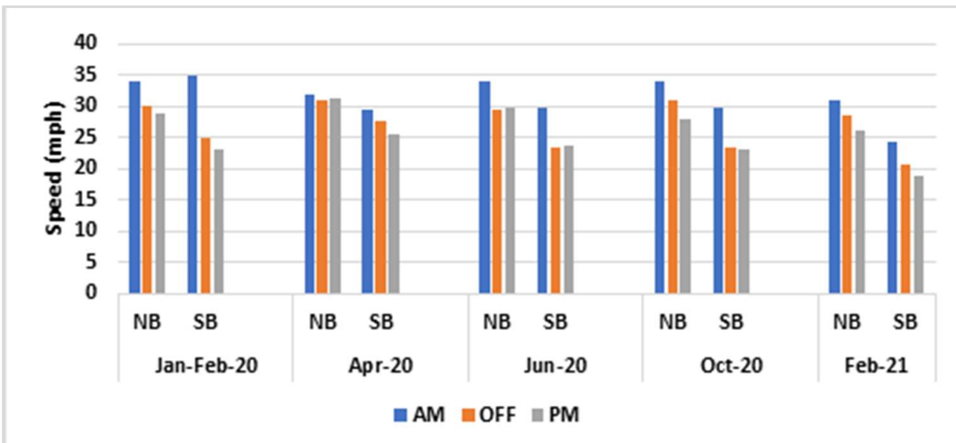

Figure 5-23. Section 5: Weekend speeds before and after CV SPaT deployment

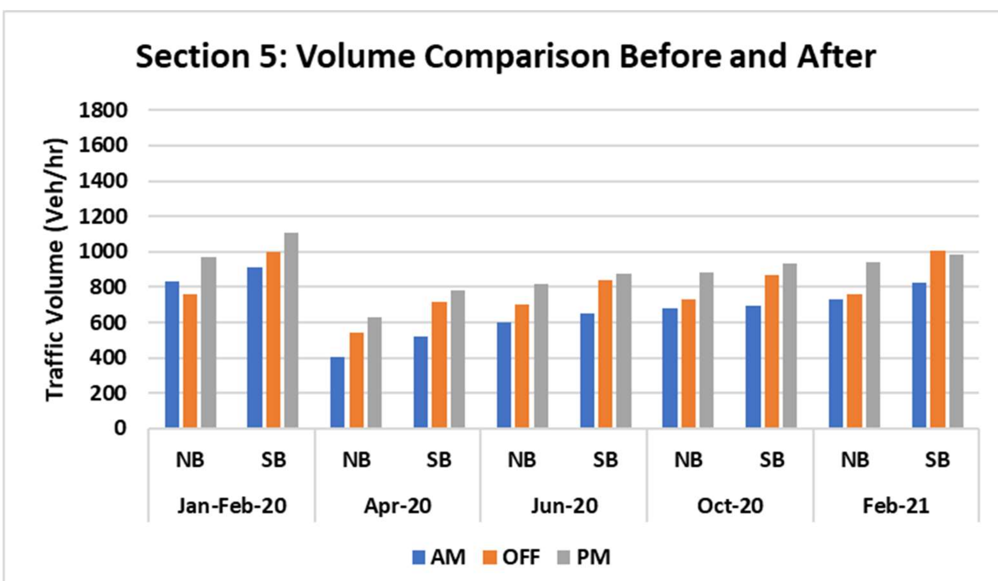

Figure 5-24. Section 5: Peak hour traffic volumes before and after CV SPaT deployment

5.3.6 – 34th St (North) – Section 6

The north part of 34th St is located between SW 20th Ave and W Univ. Ave (Section 6). The area around this section has several student housing complexes. Figure 5-25 and Figure 5-26 provide the average speeds for this section for weekdays (Tuesday, Wednesday, and Thursday) and weekend (Saturday and Sunday). The following were observed:

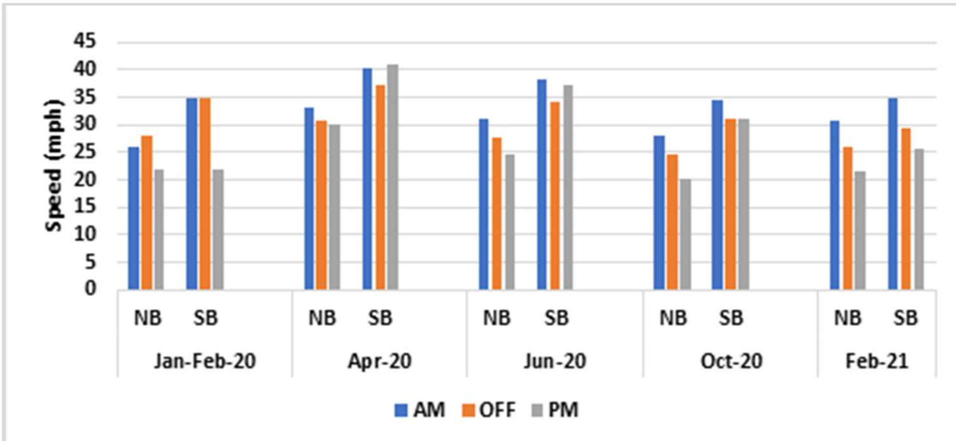

Figure 5-25. Section 6: Weekday speeds before and after CV SPaT deployment

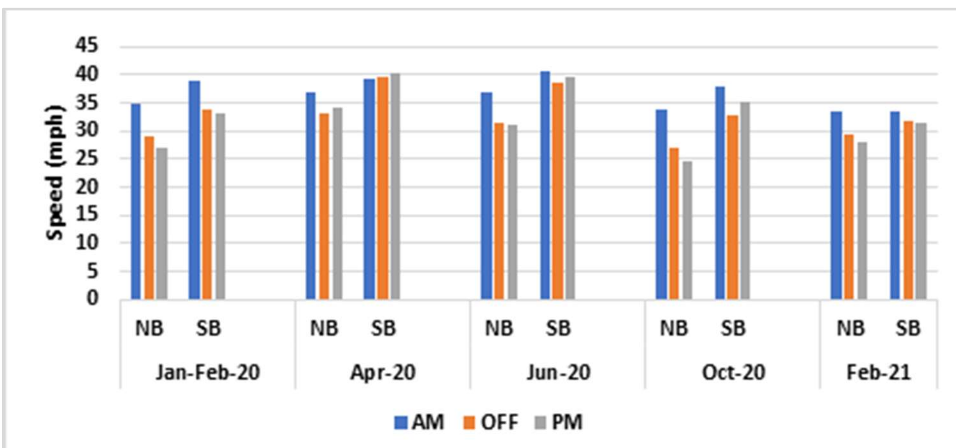

Figure 5-26. Section 6: Weekend speeds before and after CV SPaT deployment

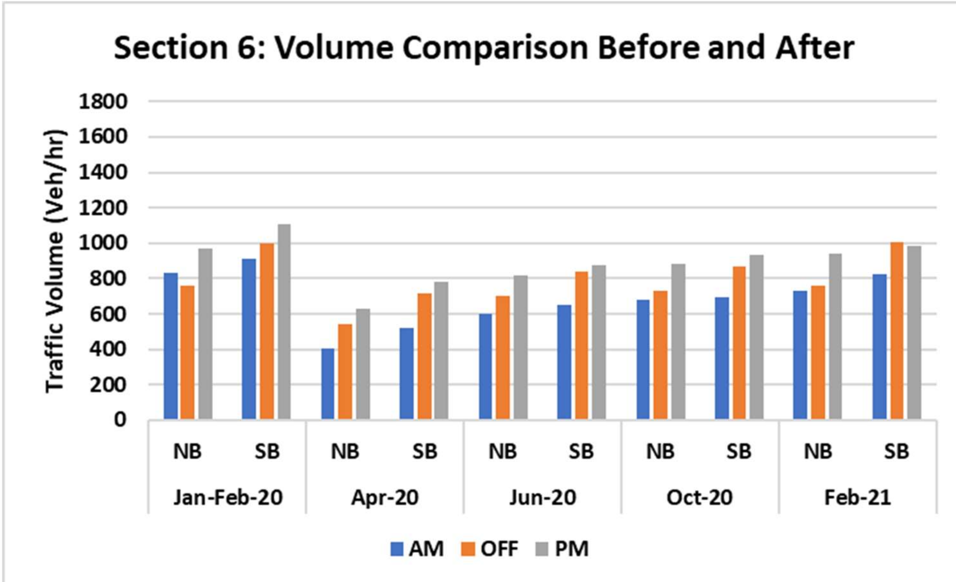

Figure 5-27. Section 6: Peak hour traffic volumes before and after CV SPaT deployment

The following were observed:

- Average speeds along this section are relatively higher than Section 5 but still lower than the speed limit (45 mph).
- Weekday average speeds are somewhat lower than those during the weekends.
- Generally, average speeds during weekdays and weekends are higher along the SB than the NB both before and after the COVID pandemic. The NB direction along this section includes two intersections (34th St @ W Univ. Ave and 34th St @ SW 2nd Ave) with heavy demands.
- The weekdays AM peak average speed in the NB direction was lower before COVID and improved after the pandemic. Also, the PM peak average speed increased significantly post-COVID, especially in the SB direction.
- Generally, the traffic volume is high before the COVID pandemic then decreases after the COVID related lockdowns and progressively increases afterwards.

5.4 – Travel Time Reliability

Travel time reliability indices for three peak periods of weekdays are estimated and shown in Table 5-16. Travel time data were obtained from the BlueARGUS database for the periods before and after CV SPaT applications, which also represent the pre- and post-COVID periods. The periods that were considered for analysis were January 27 to February 7, 2020 (before COVID), and the after COVID periods were April 12–25, 2020, June 14–27, 2020, October 11–24, 2020, and February 14–27, 2021. Two indices, travel time index and planning time index, were calculated and presented in tabular form.

Travel time index (TTI): Travel time index is the ratio of mean travel time during the analysis period to the travel time at free-flow condition. Travel time during free-flow conditions is assumed to be equal to the average minimum travel time during weekdays. TTI indicates the travel time required during congestion compared to the ideal, or free-flow travel time. For example, a TTI of 1.5 means that if the free-flow travel time is 100 s, it takes 150 s (1.5 × 100 s = 150 s) for the same trip during the analysis period.

5.4.1 – Travel Time Index (TTI)

Table 5-16 shows the TTI for each section along the Trapezium network before and after CV SPaT applications and COVID pandemic.

- The TTI is highest during the PM peak periods both before and after the COVID pandemic.
- Generally, the TTI was highest was before the COVID pandemic compared to the period after the pandemic.
- During the month of April, the highest travel time index during the PM peak was the lowest due to the onset COVID-related lockdowns when most students left for their hometowns.
- The TTI dropped following the COVID-related lockdowns and gradually increased in the months of June and October 2020 and February 2021.

Table 5-16. TTI for the road sections before and after CV SPaT applications

Month	Direction	TTI			
		Section	AM	OFF	PM
Jan–Feb 2020	Clockwise	Section 1 (EB)	2.03	1.61	2.21
		Section 2 (EB)	1.84	2.05	2.65
		Section 3 (SWB)	2.05	2.27	2.57
		Section 4 (WB)	2.1	2.24	4.77
		Section 5 (NB)	2.04	2.14	2.13
		Section 6 (NB)	2.27	2.15	2.82
	Anticlockwise	Section 1 (WB)	1.54	1.62	1.96
		Section 2 (WB)	1.74	2.35	2.52
		Section 3 (NEB)	1.95	1.94	2.68
		Section 4 (EB)	2.85	1.92	2.49
		Section 5 (SB)	3.07	3.94	6.8
		Section 6 (SB)	1.57	1.65	3.08

Table 5-16. (continued)

Month	Direction	TTI			
		Section	AM	OFF	PM
April 2020	Clockwise	Section 1 (EB)	0.89	0.93	0.93
		Section 2 (EB)	1.14	1.13	1.21
		Section 3 (SWB)	1.10	1.08	1.12
		Section 4 (WB)	1.17	1.10	1.27
		Section 5 (NB)	1.39	1.53	1.52
		Section 6 (NB)	1.30	1.43	1.43
	Anticlockwise	Section 1 (WB)	1.01	1.01	1.05
		Section 2 (WB)	0.87	0.93	0.95
		Section 3 (NEB)	1.56	1.42	1.49
		Section 4 (EB)	1.03	1.11	1.30
		Section 5 (SB)	1.53	1.81	1.87
		Section 6 (SB)	1.12	1.19	1.10
June 2020	Clockwise	Section 1 (EB)	0.96	1.00	1.00
		Section 2 (EB)	1.15	1.16	1.20
		Section 3 (SWB)	1.03	1.12	1.19
		Section 4 (WB)	1.25	1.31	1.50
		Section 5 (NB)	1.35	1.61	1.66
		Section 6 (NB)	1.37	1.57	1.71
	Anticlockwise	Section 1 (WB)	1.04	1.02	1.06
		Section 2 (WB)	0.92	1.04	1.01
		Section 3 (NEB)	1.41	1.32	1.40
		Section 4 (EB)	1.14	1.19	1.43
		Section 5 (SB)	1.70	2.09	2.12
		Section 6 (SB)	1.15	1.28	1.18
October 2020	Clockwise	Section 1 (EB)	1.00	1.01	1.09
		Section 2 (EB)	1.28	1.27	1.37
		Section 3 (SWB)	1.12	1.21	1.35
		Section 4 (WB)	1.30	1.41	1.93
		Section 5 (NB)	1.35	1.62	1.64
		Section 6 (NB)	1.51	1.79	2.15
	Anticlockwise	Section 1 (WB)	1.03	1.04	1.14
		Section 2 (WB)	1.04	1.52	1.71
		Section 3 (NEB)	1.51	1.47	1.61
		Section 4 (EB)	1.23	1.20	1.46
		Section 5 (SB)	1.75	2.15	2.70
		Section 6 (SB)	1.26	1.46	1.38

Table 5-16. (continued)

Month	Direction	TTI			
		Section	AM	OFF	PM
February 2021	Clockwise	Section 1 (EB)	1.18	1.09	1.18
		Section 2 (EB)	1.82	1.36	1.49
		Section 3 (SWB)	0.45	0.56	0.56
		Section 4 (WB)	1.34	1.52	1.91
		Section 5 (NB)	1.40	1.70	1.70
		Section 6 (NB)	1.44	1.70	1.98
	Anticlockwise	Section 1 (WB)	1.19	1.10	1.20
		Section 2 (WB)	1.61	1.70	1.98
		Section 3 (NEB)	0.84	0.82	0.88
		Section 4 (EB)	1.29	1.22	1.45
		Section 5 (SB)	1.89	2.42	3.01
		Section 6 (SB)	1.31	1.55	1.68

5.4.2 – Planning Time Index (PTI)

Planning time index is the ratio of the 95th percentile travel time to the travel time at free-flow speed. This ratio indicates the total travel time that one should plan to ensure on-time arrival. The extra time, also known as buffer time, is added to the average travel time to account for unexpected delays. For example, a PTI of 1.8 indicates that if the travel time during free-flow conditions is 100 s, one should plan to leave 80 s (1.8 × 100 s = 180 s; 180 − 100 = 80 s) earlier during the analysis period to ensure on-time arrival. Table 5-17 shows the PTI for each section of the project network before and after CV SpaT applications and COVID pandemic.

Table 5-17. PTI for the road sections before and after CV SPaT applications

Month	Direction	PTI			
		Section	AM	OFF	PM
Jan–Feb 2020	Clockwise	Section 1 (EB)	3.21	1.82	4.06
		Section 2 (EB)	2.25	2.73	5.4
		Section 3 (SWB)	3.04	2.97	4.02
		Section 4 (WB)	2.52	2.82	6.98
		Section 5 (NB)	2.76	2.93	3.03
		Section 6 (NB)	3.07	2.7	3.93
	Anticlockwise	Section 1 (WB)	1.91	2.07	3.35
		Section 2 (WB)	2.22	3.16	3.24

Table 5-17. (continued)

Month	Direction	PTI			
		Section	AM	OFF	PM
Jan–Feb 2020	Anticlockwise	Section 3 (NEB)	2.45	2.64	3.63
		Section 4 (EB)	5.34	2.37	2.87
		Section 5 (SB)	4.91	6.51	12.6
		Section 6 (SB)	1.8	2.2	5.4
April 2020	Clockwise	Section 1 (EB)	0.95	1.00	1.01
		Section 2 (EB)	1.34	1.24	1.43
		Section 3 (SWB)	1.33	1.22	1.22
		Section 4 (WB)	1.42	1.25	1.56
		Section 5 (NB)	1.58	1.74	1.79
		Section 6 (NB)	1.45	1.58	1.62
	Anticlockwise	Section 1 (WB)	1.07	1.10	1.11
		Section 2 (WB)	0.92	1.03	1.08
		Section 3 (NEB)	1.79	1.56	1.64
		Section 4 (EB)	1.13	1.29	1.58
		Section 5 (SB)	2.06	2.28	2.25
		Section 6 (SB)	1.19	1.41	1.17
June 2020	Clockwise	Section 1 (EB)	1.03	1.11	1.15
		Section 2 (EB)	1.28	1.34	1.34
		Section 3 (SWB)	1.13	1.27	1.37
		Section 4 (WB)	1.48	1.57	1.80
		Section 5 (NB)	1.50	2.01	2.13
		Section 6 (NB)	1.53	1.78	2.07
	Anticlockwise	Section 1 (WB)	1.17	1.12	1.13
		Section 2 (WB)	1.00	1.20	1.11
		Section 3 (NEB)	1.72	1.49	1.59
		Section 4 (EB)	1.29	1.37	1.75
		Section 5 (SB)	2.25	2.47	2.58
		Section 6 (SB)	1.24	1.54	1.31
October 2020	Clockwise	Section 1 (EB)	1.15	1.11	1.27
		Section 2 (EB)	1.43	1.49	1.54
		Section 3 (SWB)	1.29	1.35	1.48
		Section 4 (WB)	1.49	1.70	3.27
		Section 5 (NB)	1.65	2.03	1.98
		Section 6 (NB)	1.79	2.15	2.64
	Anticlockwise	Section 1 (WB)	1.09	1.10	1.41
		Section 2 (WB)	1.27	2.08	3.28
		Section 3 (NEB)	1.72	1.61	1.79

Table 5-17. (continued)

Month	Direction	PTI			
		Section	**AM**	**OFF**	**PM**
		Section 4 (EB)	1.67	1.45	1.79
		Section 5 (SB)	2.10	2.57	4.05
		Section 6 (SB)	1.39	1.84	1.65
February 2021	Clockwise	Section 1 (EB)	1.32	1.20	1.40
		Section 2 (EB)	2.98	1.59	1.71
		Section 3 (SWB)	0.52	0.67	0.68
		Section 4 (WB)	1.56	1.88	2.78
		Section 5 (NB)	1.80	2.11	2.05
		Section 6 (NB)	1.61	2.13	2.66
	Anticlockwise	Section 1 (WB)	1.34	1.19	1.38
		Section 2 (WB)	2.70	2.25	2.78
		Section 3 (NEB)	0.97	0.93	1.03
		Section 4 (EB)	1.92	1.49	1.78
		Section 5 (SB)	2.21	3.16	4.37
		Section 6 (SB)	1.50	1.85	2.41

The PTI shows a similar trend as the TTI.

- The PTI is highest during the PM peak periods both before and after the COVID pandemic.
- The PTI was highest before the COVID pandemic compared to the period after the pandemic.
- During the month of April, the highest planning time index during the PM peak was the lowest due to the onset COVID-related lockdowns when most students left for their hometowns.
- The PTI dropped following the COVID-related lockdowns and gradually increased in the months of June and October 2020 and February 2021.

Generally, both reliability indices are highest during the PM peak period. Consistent with the previous analysis, PM peak periods have the worst performance. The reliability indices have improved after the CV SPaT applications and COVID pandemic.

5.5 – OBU User Experience

Drivers of vehicles equipped with on-board units were interviewed on June 21, 2021, in order to understand their perception and use of the OBU technology. This interview solicited input from various perspectives. Two persons each from UF facilities, UF research, and CoG were present during the Zoom call. The transit bus drivers from RTS were not involved in discussions because the OBUs installed in transit buses do not have a screen. The discussions started with leading questions outlined in Appendix C.

The following subsections summarize the discussions with OBU users.

5.5.1 – Usage

- CoG staff used the OBU once or twice a week, whereas UF facilities staff used it on a daily basis. UF researchers used it less frequently than others do.
- Two units within UF facilities (both hybrid cars) had issues with battery drainage. UF facilities staff directly attributed this issue to OBUs. Siemens had addressed this problem in March 2021; however, the problem has since returned on the two hybrid vehicle units.

5.5.2 – Functionality

- When the vehicles and OBU were turned on and driving in the Trapezium area, the users said they received messages approximately 90% of the time from RSUs. None of the users received any OBU-to-OBU messages.
- All users reported that they sometimes got "do not enter", wrong-way driving warnings even though they were in a lane in the direction of travel. This could be due to inaccuracy in GPS and the OBU thinking that they were in the adjacent lane opposite to the direction of travel.
- One user reported that they received a "pedestrians in the area" warning even though there were no pedestrians at all. Emmanuel Posadas (Traffic Operations Manager, CoG) confirmed that the pedestrian recall button was "on" at the particular intersection leading to OBU sending such messages.
- The speed limit on W Univ. Ave has recently been lowered. One user identified that the speed limit has not been updated on the OBUs yet.

5.5.3 – Usefulness of Messages and Warnings

- Users said that the "x seconds of red remaining" messages were not reliable at the beginning of the red because this number would be fluctuating. However, after other phases were served and the OBU started showing less than 10 seconds remaining to "end of red" or "start of the green", the information was reliable.
- One user acknowledged that having the information that only a few seconds of green remained could motivate them to drive faster to get through a particular intersection without having to stop. Other users said that they would also do the same in their personal vehicles. However, they would drive more conservatively with their work vehicles.

- One user said that some of the messages could be distracting, whereas most users found that the OBU helped increase their awareness of the surroundings. For example, one user said that pedestrian warnings on the app made them actively look around and watch for pedestrians.
- Overall, the users found the signal timing messages to be useful and said other warnings need to be fine-tuned.

5.5.4 – Recommended Improvements

- Some users reported that they saw messages with a very large number of seconds (2,000– 3,000) of green remaining. This happened when they drove on a major street, where there were no actuations on an adjoining minor street. Users suggested that it would be better to hide such large numbers because they are not very insightful. As a general comment, one user noted that the screen should only display information that has a high degree of confidence.
- Improving GPS accuracy would stop irrelevant warnings from being shown.
- Most of the UF facilities drivers drove within campus. They suggested that in addition to the periphery of campus (i.e., Trapezium corridors), it would be helpful if OBUs were functional within the campus as well.
- Some users suggested that auditory warnings coupled with visual warnings would be better than visual warnings alone. This suggestion is backed by research conducted at UFTI on another project with eye trackers. It has been shown in the research that auditory warnings lead to less distraction and improved driving experience.
- One user suggested that it would be cumbersome to use two different screens for navigation and warnings. It would be helpful to integrate the OBU applications and navigation functionalities within one system.

Chapter 6 – Conclusions

The aim of this project was to evaluate the efficacy of DSRC Connected Vehicle technology in improving efficiency and safety within a network of signalized intersections. We began by initiating an in-depth study of the state of the Gainesville SPaT Trapezium before the deployment of connected vehicle (CV) applications i.e., the “before” study of operations and safety on the corridors making up the Trapezium (Chapter 2), which summarized the crash data analysis based on data from the Signal Four Analytics database, followed by the operational analysis results of seven signalized intersections. Detector data from CoG for each of the intersections were use d to represent traffic demand. The travel time and speed data trends obtained along from BlueArgus for the four major corridors of the Trapezium network were presented. In Chapter 3, a description of the software architecture and workflow developed to collect data along the Trapezium was provided. Chapter 4 summarized the development of suitable tools and software to analyze, and process connected vehicle (CV) data obtained from the deployed system at regular intervals during the project. Chapter 5 presented the “after” study and compared it with the “before” study in Chapter 2. It reviewed the differences in operational performance, crashes, speed, and travel time analysis after the deployment of CV technologies.

Due to the timeline of the project coinciding with that of the COVID pandemic, it would be difficult to separate the effects of the pandemic and the SPaT deployments on safety and traffic operations on Gainesville Trapezium area. Nonetheless, the following conclusions can be made from the “before-after” evaluation of the Gainesville SPaT Trapezium.

6.1 – Safety

- All types of crashes (vehicle, bicyclist, and pedestrians) decreased in the after period. Most of this can be attributed to a decrease in Friday and Saturday night crashes on W Univ. Ave. With few students and limited nightlife, the crashes during this period decreased.
- The crash period considered for the analysis of before and after the CV SPaT applications was short due to a shorter “after” period. Ideally, crash records over 2–3 years could provide better insights for comparison.

6.2 – Traffic Operations

- An automated process was developed to collect the turning movement counts, input them in to HCS, and generate intersection delays.
- Most intersections had a significant drop in intersection delays immediately after COVID-related

lockdowns. Over the last year (2020), as the traffic volumes have recovered, delay levels have steadily increased, gradually approaching pre-COVID levels.

- A fully automated system such as the one developed and presented in this report could be a very useful tool in continual evaluation of a traffic network to study the effects of various system changes (for example, special events, natural disasters, and infrastructure changes, etc.).

6.3 – Speed and Travel Time Reliability

- Speed and travel time analysis were conducted using Bluetooth data. The entire Trapezium network was broken into six sections based on locations of the Bluetooth stations.
- For most sections, the speeds either remained at the same level of increase as in April 2020, followed by gradual decrease in speeds over the months of June, August, and October 2020. For February 2021, the speeds were either similar or lower than pre-COVID (Jan.–Feb. 2020) speeds.

The TTI dropped following the COVID-related lockdowns and gradually increased in the months of June and October 2020 and February 2021.

6.4 – OBU User Experience

- Drivers of vehicles equipped with on-board units (OBUs) were interviewed to understand their perception and use of the OBU technology.
- Overall, the users found the signal timing messages to be useful and said other warnings need to be fine-tuned.
- The users suggested improvements to the OBU, such as providing auditory warnings and integration with a navigation system.

We hope this report will provide valuable insights into various processes involved and challenges faced in deploying and utilizing DSRC and other connected vehicle technologies along an important urban arterial road network.

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Appendix A – Input Data Tables and Results of the Signalized Intersections

A.1 – Intersection Overviews and Input Data for Signalized Intersections

A.1.1 – W Univ. Ave at 34th St

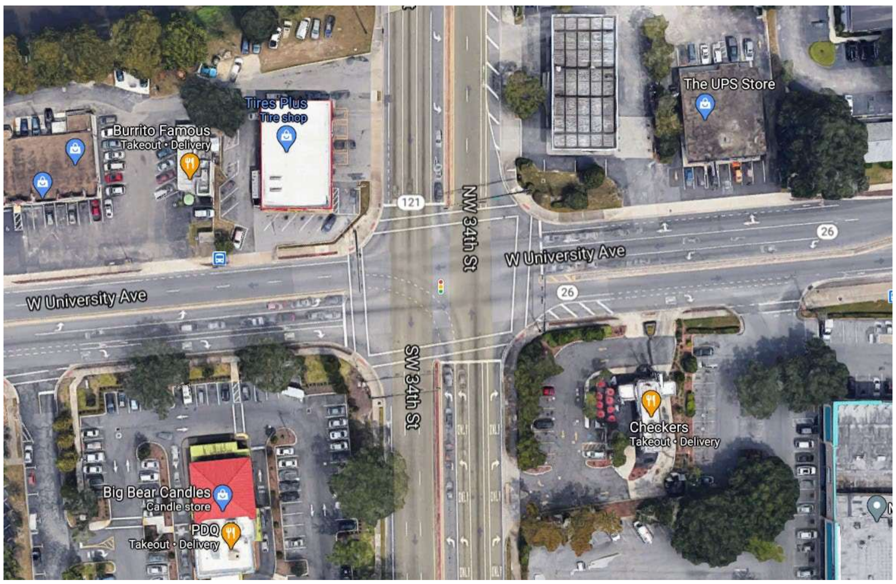


Figure A-1. Layout and lane configuration for the intersection at W Univ. Ave and 34th St

Table A-1. Geometric data for the intersection at W Univ. Ave and 34th St

Geometric Data	EB			WB			NB				SB			
	L	Th	R	L	Th	Th/R	L	L	Th	R	L	Th	Th	Th/R
Total walkway width(ft)	10			10			10				10			
Crosswalk width (ft)	10			10			10				10			
Crosswalk length (ft)	110			110			90				80			
Corner radius (ft)	50			70			40				60			
Number of lanes	3			3			4				4			
Average lane width(ft)	11			11			11				11			
Number of receiving lanes (ln)	1			2			2				3			
Turn bay length (ft)	250	—	220	240	—	—	250	490	—	490	180	—	—	—
Presence of on-street parking	0			0			0				0			
Approach grade (%)	0			0			0				0			

Table A-2. Traffic characteristics for the intersection at W Univ. Ave and 34th St

Traffic Characteristics	EB			WB			NB			SB		
	L	Th	R	L	Th	R	L	Th	R	L	Th	R
Traffic flow rate (veh/h)	44	224	80	180	536	116	372	596	128	80	876	180
RTOR flow rate (veh/h)	0			0			0			0		
Percentage heavy vehicles	3	3	3	3	3	3	3	3	3	3	3	3
Platoon ratio	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Upstream filtering adjustment factor	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Initial queue (veh)	0	0	0	0	0	0	0	0	0	0	0	0
Pedestrian flow rate (ped/h)	100			100			100			100		
Bicycle flow rate (bicycle/h)	0			0			0			0		
On-street parking maneuver rate (veh/h)	0			0			0			0		
Local bus stopping rate(bus/h)	2			2			2			2		
Midsegment 85th percentile speed (mi/h)	35			35			35			35		
Number of right-turn islands	0			0			0			0		

Table A-3. Traffic counts for the intersection at W Univ. Ave and 34th St

Period	Time	EB			WB			NB			SB		
		L	Th	R	L	Th	R	L	Th	R	L	Th	R
AM peak	0730–0745	3	92	50	26	88	19	58	142	39	27	202	41
	0745–0800	6	106	38	34	117	26	54	100	30	21	197	40
	0800–0815	8	91	19	26	91	20	58	117	42	22	199	41
	0815–0830	7	98	23	28	96	21	47	108	33	22	179	37
Off-peak	1200–1215	14	71	17	37	93	20	53	116	23	22	190	39
	1215–1230	16	70	15	33	87	19	51	113	27	22	188	39
	1230–1245	16	68	19	38	91	20	53	113	25	21	203	42
	1245–1300	14	71	15	41	100	22	58	121	23	20	200	41
PM peak	1630–1645	11	49	19	40	130	28	85	143	30	17	208	43
	1645–1700	11	56	20	45	134	29	93	149	32	20	219	45
	1700–1715	15	48	21	42	129	28	88	140	30	22	200	41
	1715–1730	11	54	24	41	147	32	97	141	30	24	209	43

Table A-4. Signal timing data for the intersection at W Univ. Ave and 34th St

Phase Information	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Maximum Green (G_{max}) or Phase Split, s	25.0	45.0	25.0	45.0	25.0	45.0	25.0	45.0
Yellow Change Interval (Y), s	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Red Clearance Interval (R_c), s	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Minimum Green (G_{min}), s	4	15	6	15	7	15	4	15
Start-Up Lost Time (lt), s	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Extension of Effective Green (e), s	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Passage (PT), s	2.5	3.5	3.5	3.5	3.5	3.5	2.5	3.5
Recall Mode	Off	Off	Off	Off	Off	Min	Off	Min
Dual Entry	No	Yes	No	Yes	No	Yes	No	Yes
Walk (*Walk*), s	——	7.0	——	7.0	——	7.0	——	7.0
Pedestrian Clearance Time (PC), s	——	35.0	——	34.0	——	28.0	——	25.0

A.1.2 – W Univ. Ave at Gale Lemerand Dr

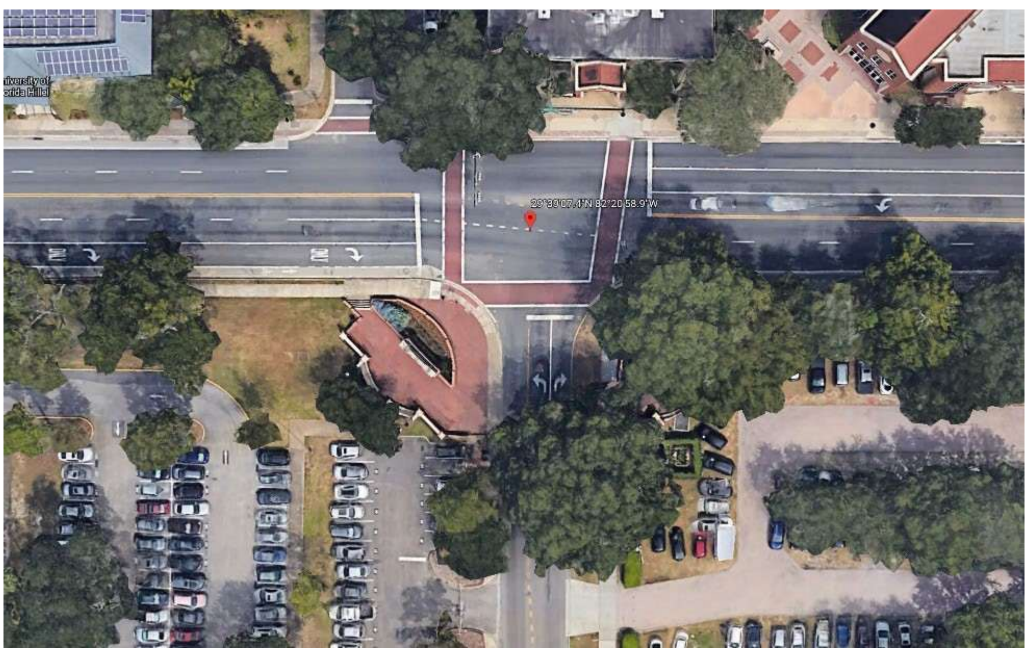


Figure A-2. Layout and lane configuration for the intersection at W Univ. Ave and Gale Lemerand Dr

Table A-5. Geometric data for the intersection at W Univ. Ave and Gale Lemerand Dr

Geometric Data	EB		WB		NB	
	Th	R	L	Th	L	R
Total walkway width (ft)	6		10		10	
Crosswalk width (ft)	11		N/A		10	
Crosswalk length (ft)	60		N/A		65	
Corner radius (ft)	30		N/A		30	
Number of lanes	3		3		2	
Average lane width (ft)	11		11		11	
Number of receiving lanes (ln)	2		2		—	
Turn bay length (ft)	290	300	340	520	110	100
Presence of on-street parking	0		0		0	
Approach grade (%)	0		0		0	

Table A-6. Traffic characteristics for the intersection at W Univ. Ave and Gale Lemerand Dr

Traffic Characteristics	EB		WB		NB	
	Th	R	L	Th	L	R
Traffic flow rate (veh/h)	804	60	180	820	60	32
RTOR flow rate (veh/h)	0		N/A		100	
Percentage heavy vehicles	2%	0%	3%	1%	0%	6%
Platoon ratio	1.0	1.0	1.0	1.0	1.0	1.0
Upstream filtering adjustment factor	1.0	1.0	1.0	1.0	1.0	1.0
Initial queue (veh)	5	0	1	2	2	0
Base saturation flow	1,900	1,900	1,900	1,900	1,900	1,900
Pedestrian flow rate (ped/h)	0		4		88	
Bicycle flow rate (bicycles/h)	0		0		0	
On-Street parking maneuver rate (veh/h)	0		0		0	
Local bus stopping rate (buses/h)	0		0		0	
Midsegment 85th percentile speed (mi/h)	30		30		20	
Number of right-turn islands	0		0		0	

Table A-7. Traffic counts for the intersection at W Univ. Ave and Gale Lemerand Dr

Period	Time	EB			WB			NB			SB		
		L	T	R	L	T	R	L	T	R	L	T	R
AM peak	0730–0745	0	178	58	42	187	0	13	0	15	0	0	0
	0745–0800	0	176	41	40	193	0	12	0	18	0	0	0
	0800–0815	0	175	45	34	160	0	13	0	19	0	0	0
	0815–0830	0	188	40	40	163	0	18	0	17	0	0	0
Off-peak	1200–1215	0	173	16	29	173	0	22	0	14	0	0	0
	1215–1230	0	180	20	28	171	0	27	0	16	0	0	0
	1230–1245	0	188	24	30	177	0	32	0	20	0	0	0
	1245–1300	0	179	21	27	189	0	29	0	21	0	0	0
PM peak	1630–1645	0	198	22	25	209	0	39	0	35	0	0	0
	1645–1700	0	223	24	23	204	0	41	0	28	0	0	0
	1700–1715	0	205	21	26	214	0	40	0	32	0	0	0
	1715–1730	0	221	19	27	267	0	40	0	33	0	0	0

Table A-8. Signal timing data for the intersection at W Univ. Ave and Gale Lemerand Dr

Phase Information	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Maximum Green (G_{max}) or Phase Split, s	——	45	25	65	——	35	——	——
Yellow Change Interval (Y), s	——	3.7	3.7	3.7	——	3.4	——	——
Red Clearance Interval (R_c), s	——	2	2	2	——	3.2	——	——
Minimum Green (G_{min}), s	——	12	5	12	——	4	——	——
Start-Up Lost Time (lt), s	——	2	2	2	2	——	——	——
Extension of Effective Green (e), s	——	2	2	2	2	——	——	——
Passage (PT), s	——	2	2	2	——	2	——	——
Recall Mode	——	Min	Min	Off	——	Off	——	——
Dual Entry	——	Yes	No	Yes	——	No	——	——
Walk (*Walk*), s	——	7	——	——	——	7	——	——
Pedestrian Clearance Time (PC), s	——	18	——	——	——	21	——	——

A.1.3 – W Univ. Ave at 17th St

Figure A-3. Layout and lane configuration for the intersection at W Univ. Ave and 17th St

Table A-9. Geometric data for the intersection at W Univ. Ave and 17th St

Geometric Data	EB		WB		NB			SB		
	L	Th	L	Th	L	Th	R	L	Th	R
Number of lanes	3		3		2			1		
Average lane width (ft)	11		11		11			11		
Number of receiving lanes (ln)	2		2		1			1		
Turn bay length (ft)	130	410	130	860	130	320	320	185	185	185
Presence of on-street parking	Y		Y		N			N		
Approach grade (%)	0		0		0			0		
Total walkway width (ft)	10		10		10			10		
Crosswalk width (ft)	10		10		10			10		
Crosswalk length (ft)	64		64		52			52		
Corner radius (ft)	15		15		20			20		

Table A-10. Traffic characteristics for the intersection at W Univ. Ave and 17th St

Traffic Characteristics	EB		WB		NB			SB		
	L	Th	L	Th	L	Th	R	L	Th	R
Traffic flow rate (veh/h)	20	520	8	692	8	20	8	16	20	36
RTOR flow rate (veh/h)	0		0		12			24		
Percentage heavy vehicles	0%	5%	0%	2%	0%	0%	0%	4%	0%	4%
Platoon ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream filtering adjustment factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Initial queue (veh)	0	2	0	3	0	1	0	1	0	0
Base saturation flow	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900
Pedestrian flow rate (ped/h)	12		4		8			12		
Bicycle flow rate (bicycle/h)	0		0		0			0		
On-Street parking maneuver rate (veh/h)	0		0		0			0		
Local bus stopping rate (bus/h)	0		0		0			0		
Midsegment 85th percentile speed (mi/h)	30		30		30			30		
Number of right-turn islands	0		0		0			0		

Table A-11. Traffic counts for the intersection at W Univ. Ave and 17th St

Period	Time	EB			WB			NB			SB		
		L	T	R	L	T	R	L	T	R	L	T	R
AM peak	0730–0745	8	187	10	8	199	10	14	3	4	13	6	16
	0745–0800	8	179	9	12	209	11	18	3	5	18	8	23
	0800–0815	11	178	9	8	180	9	17	3	6	15	7	20
	0815–0830	15	196	10	11	172	9	18	5	8	9	4	12
Off-peak	1200–1215	16	175	9	9	155	8	16	3	5	7	4	10
	1215–1230	13	192	10	11	162	9	14	3	5	8	4	10
	1230–1245	18	206	11	12	171	9	18	4	7	9	4	11
	1245–1300	16	196	11	9	181	10	16	4	6	9	4	12
PM peak	1630–1645	23	241	13	10	178	9	22	9	14	9	4	12
	1645–1700	20	233	12	11	200	11	25	7	11	10	5	13
	1700–1715	19	218	11	11	184	10	33	12	18	10	5	13
	1715–1730	18	259	14	9	200	11	28	10	16	10	5	13

Table A-12. Signal timing data for the intersection at W Univ. Ave and 17th St

Phase Information	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Maximum Green (G_{max}) or Phase Split, s	25	55	25	55	25	55	—	40
Yellow Change Interval (*Y*), s	4	3.7	4	3.7	4	3.4	—	3.4
Red Clearance Interval (R_c), s	2	2	2	2	2.2	2.4	—	2.4
Minimum Green (G_{min}), s	5	12	5	12	5	4	—	4
Start-Up Lost Time (*lt*), s	2	2	2	2	2	2	2	2
Extension of Effective Green (*e*), s	2	2	2	2	2	2	2	2
Passage (*PT*), s	2.5	3.5	2.5	3.5	2	3	—	2
Recall Mode	Off	Min	Off	Min	Off	Off	—	Off
Dual Entry	No	Yes	No	Yes	No	Yes	—	Yes
Walk (*Walk*), s	—	7	—	7	—	7	—	7
Pedestrian Clearance Time (*PC*), s	—	14	—	12	—	19	—	19

A.1.4 – W Univ. Ave at 13th St

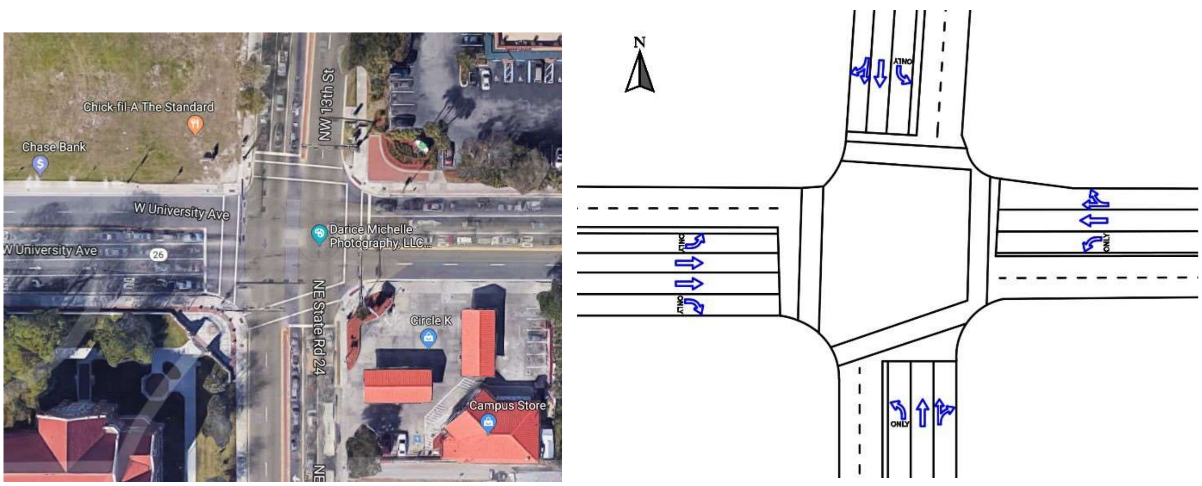


Figure A-4. Layout and lane configuration for the intersection at W Univ. Ave and 13th St

Table A-13. Geometric data for the intersection at W Univ. Ave and 13th St

Geometric Data	EB			WB			NB			SB		
	L	Th	R	L	Th	R	L	Th	R	L	Th	R
Number of lanes		4			3			3			3	
Average lane width (ft)		11			11			11			11	
Number of receiving lanes (ln)		2			2			2			2	
Turn bay length (ft)	450	999	240	240	999	—	310	999	—	470	999	—
Presence of on-street parking		0			0			0			0	
Approach grade (%)		0			0			0			0	
Total walkway width (ft)		10			10			10			10	
Crosswalk width (ft)		10			10			10			10	
Crosswalk length (ft)		70			70			75			70	
Corner radius (ft)		30			30			35			20	

Table A-14. Traffic characteristics for the intersection at W Univ. Ave and 13th St

Traffic Characteristics	EB			WB			NB			SB		
	L	Th	R	L	Th	R	L	Th	R	L	Th	R
Traffic flow rate (veh/h)	184	504	216	116	372	84	144	1100	328	76	488	100
RTOR flow rate (veh/h)		0			0			0			0	
Percentage heavy vehicles	3	3	3	3	3	3	3	3	3	3	3	3
Platoon ratio	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Upstream filtering adjustmentfactor	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Initial queue (veh)	0	0	0	0	0	0	0	0	0	0	0	0
Pedestrian flow rate (ped/h)		104			204			76			212	
Bicycle flow rate (bicycle/h)		0			0			0			0	
On-Street parking maneuver rate (veh/h)		0			0			0			0	
Local bus stopping rate (bus/h)		2			2			2			2	
Midsegment 85th percentile speed (mi/h)		30			30			30			30	
Number of right-turn islands		0			0			0			0	

Table A-15. Traffic counts for the intersection at W Univ. Ave and 13th St

Period	Time	EB			WB			NB			SB		
		L	T	R	L	T	R	L	T	R	L	T	R
AM peak	0730–0745	17	109	47	28	132	29	24	170	51	18	263	54
	0745–0800	20	109	47	30	131	29	23	177	53	18	208	43
	0800–0815	20	100	43	33	112	25	26	176	53	28	219	45
	0815–0830	17	107	46	30	108	24	25	146	44	37	227	47
Off-peak	1200–1215	30	95	41	32	93	20	43	167	50	28	99	20
	1215–1230	26	96	41	29	91	20	42	165	50	27	112	23
	1230–1245	30	94	41	31	98	22	46	161	48	23	116	24
	1245–1300	28	102	44	32	95	21	40	178	53	27	109	22
PM peak	1630–1645	41	121	52	26	105	23	49	257	77	19	113	23
	1645–1700	36	127	54	20	101	22	43	264	79	19	123	25
	1700–1715	40	134	58	29	114	25	44	241	72	19	108	22
	1715–1730	46	126	54	28	93	21	36	275	82	19	122	25

Table A-16. Signal timing data for the intersection at W Univ. Ave and 13th St

Phase Information	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Maximum Green (*Gmax*) or Phase Split, s	25	45	25	45	30	70	25	55
Yellow Change Interval (*Y*), s	3.7	3.7	3.7	3.7	3.8	3.8	3.8	3.8
Red Clearance Interval (*Rc*), s	2	2	2	2	2	2	2	2
Minimum Green (*Gmin*), s	7	12	7	12	7	12	7	12
Start-Up Lost Time (*lt*), s	2	2	2	2	2	2	2	2
Extension of Effective Green (*e*), s	2	2	2	2	2	2	2	2
Passage (*PT*), s	3	3.5	3	3.5	3	3.5	2.5	3.5
Recall Mode	Off	Off	Off	Off	Off	Off	Off	Off
Dual Entry	No	Yes	No	Yes	No	Yes	No	Yes
Walk (*Walk*), s	——	7	——	7	——	7	——	7
Pedestrian Clearance Time (*PC*), s	——	24	——	22	——	22	——	23

A.1.5 – SW 8th Ave at 13th St

Figure A-5. Layout and lane configuration for the intersection at SW 8th Ave and 13th St

Table A-17. Geometric data for the intersection at SW 8th Ave and 13th St

Geometric Data	EB				WB		NB			SB		
	L	L	Th	R	L	Th/R	L	Th	Th/R	L	Th	Th/R
Total walkway width (ft)	10				10		10			10		
Crosswalk width (ft)	10				10		10			10		
Crosswalk length (ft)	86				65		40			76		
Corner radius (ft)	70				15		20			25		
Number of lanes	4				3		3			3		
Average lane width (ft)	11				11		11			11		
Number of receiving lanes (ln)	1				1		2			2		
Turn bay length (ft)	160	275	—	210	180	—	200	—	—	230	—	—
Presence of on-street parking	0				0		0			0		
Approach grade (%)	0				0		0			0		

Table A-18. Traffic characteristics for the intersection at SW 8th Ave and 13th St

Traffic Characteristics	EB			WB			NB			SB		
	L	Th	R	L	Th	R	L	Th	R	L	Th	R
Traffic flow rate (veh/h)	128	72	8	76	72	8	68	628	56	68	1,100	124
RTOR flow rate (veh/h)	0			0			0			0		
Percentage heavy vehicles	3	3	3	3	3	3	3	3	3	3	3	3
Platoon ratio	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Upstream filtering adjustmentfactor	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Initial queue (veh)	0	0	0	0	0	0	0	0	0	0	0	0
Pedestrian flow rate (ped/h)	—			—			—			—		
Bicycle flow rate (bicycle/h)	0			0			0			0		
On-Street parking maneuver rate (veh/h)	0			0			0			0		
Local bus stopping rate (bus/h)	2			2			2			2		
Midsegment 85th percentile speed (mi/h)	30			30			30			30		
Number of right-turn islands	0			0			0			0		

Table A-19. Traffic counts for the intersection at SW 8th Ave and 13th St

Period	Time	EB			WB			NB			SB		
		L	T	R	L	T	R	L	T	R	L	T	R
AM peak	0730–0745	68	39	5	17	39	4	115	144	11	20	284	32
	0745–0800	76	37	4	22	37	4	123	147	11	16	293	33
	0800–0815	64	37	4	19	37	4	112	136	12	17	262	29
	0815–0830	44	38	4	18	38	4	93	118	9	16	232	26
Off-peak	1200–1215	37	31	3	21	31	3	95	122	10	16	212	24
	1215–1230	37	34	4	18	34	4	99	134	11	17	205	23
	1230–1245	37	41	5	19	41	5	97	135	11	17	230	26
	1245–1300	40	29	3	23	29	3	92	129	11	21	235	26
PM peak	1630–1645	32	18	2	19	18	2	119	157	14	17	275	31
	1645–1700	26	17	2	23	17	2	107	147	13	15	252	28
	1700–1715	24	16	2	16	16	2	123	154	14	16	305	34
	1715–1730	17	12	1	18	12	1	83	126	13	17	276	31

Table A-20. Signal timing data for the intersection at SW 8th Ave and 13th St

Phase Information	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Maximum Green (G_{max}) or Phase Split, s	25.0	35.0	25.0	35.0	25.0	70.0	25.0	65.0
Yellow Change Interval (Y), s	3.4	3.4	3.4	3.4	3.9	3.9	3.9	3.9
Red Clearance Interval (R_c), s	3.1	3.2	3.2	3.2	2.0	2.0	2.0	2.0
Minimum Green (G_{min}), s	7	4	5	4	5	12	5	12
Start-Up Lost Time (lt), s	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Extension of Effective Green (e), s	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Passage (PT), s	2.5	3.0	2.5	3.0	2.5	3.5	2.5	3.5
Recall Mode	Off	Min	Off	Off	Off	Max	Off	Max
Dual Entry	No	Yes	No	Yes	No	Yes	No	Yes
Walk ($Walk$), s	——	7.0	——	7.0	——	7.0	——	7.0
Pedestrian Clearance Time (PC), s	——	22.0	——	19.0	——	12.0	——	18.0

A.1.6 – Archer Rd at 13th St

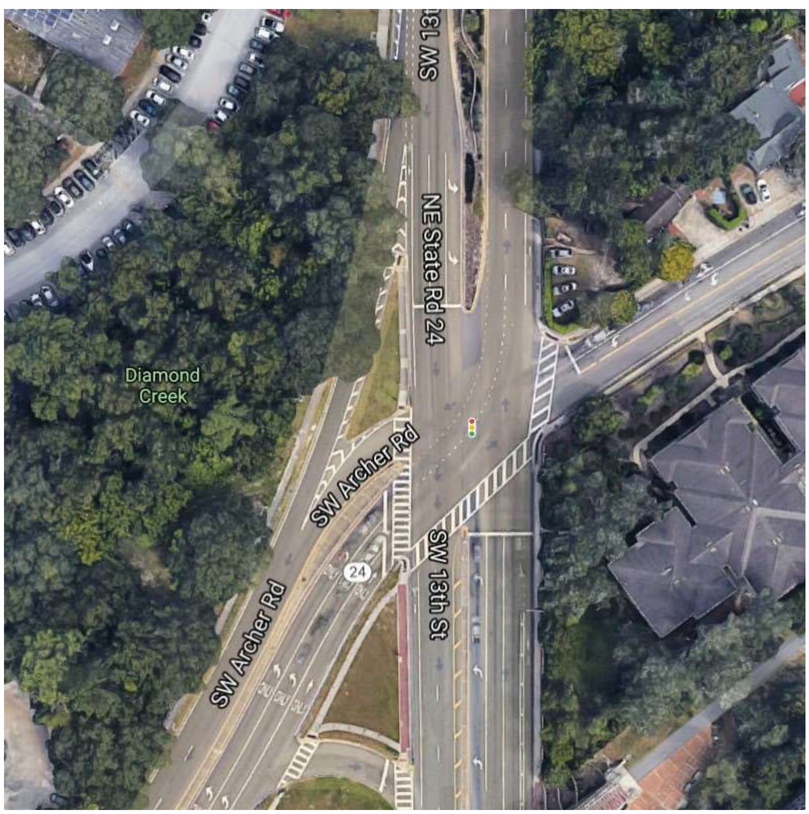


Figure A-6. Layout and lane configuration for the intersection at Archer Rd and 13th St

Table A-21. Geometric data for the intersection at Archer Rd and 13th St

Geometric Data	EB		WB			NB			SB		
	L	Th	L	Th	R	L	Th	R	L	Th	R
Total walkway width (ft)	10		10			10			10		
Crosswalk width (ft)	10		10			10			10		
Crosswalk length (ft)	110		N/A			60			95		
Corner radius (ft)	5		15			20			3		
Number of lanes	3		2			3			3		
Average lane width (ft)	11		11			11			11		
Number of receiving lanes (ln)	1		1			2			2		
Turn bay length (ft)	—	430	—	260	260	170	—	—	100	—	—
Presence of on-street parking	0		0			0			0		
Approach grade (%)	0		0			0			0		

Table A-22. Traffic characteristics for the intersection at Archer Rd and 13th St

Traffic Characteristics	EB			WB			NB			SB		
	L	Th	R	L	Th	R	L	Th	R	L	Th	R
Traffic flow rate (veh/h)	600	268	52	40	92	12	52	584	32	28	1,140	80
RTOR flow rate (veh/h)	0			0			0			0		
Percentage heavy vehicles	3	3	3	3	3	3	3	3	3	3	3	3
Platoon ratio	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Upstream filtering adjustmentfactor	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Initial queue (veh)	0	0	0	0	0	0	0	0	0	0	0	0
Pedestrian flow rate (ped/h)	50			—			50			50		
Bicycle flow rate (bicycles/h)	0			0			0			0		
On-Street parking maneuver rate (veh/h)	0			0			0			0		
Local bus stopping rate (buses/h)	2			2			2			2		
Midsegment 85th percentile speed (mi/h)	30			30			30			30		
Number of right-turn islands	0			0			0			0		

Table A-23. Traffic counts for the intersection at Archer Rd and 13th St

Period	Time	EB			WB			NB			SB		
		L	T	R	L	T	R	L	T	R	L	T	R
AM peak	0730–0745	118	33	7	15	57	6	18	143	7	6	217	13
	0745–0800	140	25	5	16	53	6	20	171	9	7	236	14
	0800–0815	131	20	4	13	48	5	19	168	9	5	227	13
	0815–0830	106	20	4	9	43	5	18	127	7	4	190	11
Off-peak	1200–1215	112	23	5	8	21	2	14	115	7	8	182	12
	1215–1230	107	31	6	6	26	3	14	107	6	8	176	12
	1230–1245	119	32	7	8	29	3	16	118	7	7	206	13
	1245–1300	108	31	6	9	30	3	14	112	6	9	203	14
PM peak	1630–1645	150	67	13	10	23	3	13	146	8	7	285	20
	1645–1700	139	61	12	10	30	3	10	113	6	9	263	18
	1700–1715	144	69	14	12	23	3	13	139	8	11	260	22
	1715–1730	142	73	15	14	28	3	14	122	7	8	247	20

Table A-24. Signal timing data for the intersection at Archer Rd and 13th St

Phase Information	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Maximum Green (G_{max}) or Phase Split, s	——	60.0	——	30.0	20.0	60.0	——	60.0
Yellow Change Interval (Y), s	——	4.3	——	3.7	4.0	4.4	——	4.4
Red Clearance Interval (R_c), s	——	2.2	——	3.1	2.0	2.4	——	2.4
Minimum Green (G_{min}), s	——	6	——	6	6	6	——	6
Start-Up Lost Time (lt), s	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Extension of Effective Green (e), s	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Passage (PT), s	——	2.0	——	2.0	2.0	2.0	——	2.0
Recall Mode	——	Off	——	Off	Off	Min	——	Min
Dual Entry	——	Yes	——	Yes	No	Yes	——	Yes
Walk (*Walk*), s	——	7.0	——	0.0	——	7.0	——	7.0
Pedestrian Clearance Time (PC), s	——	33.0	——	19.0	——	0.0	——	28.0

A.1.7 – Archer Rd at 34th St

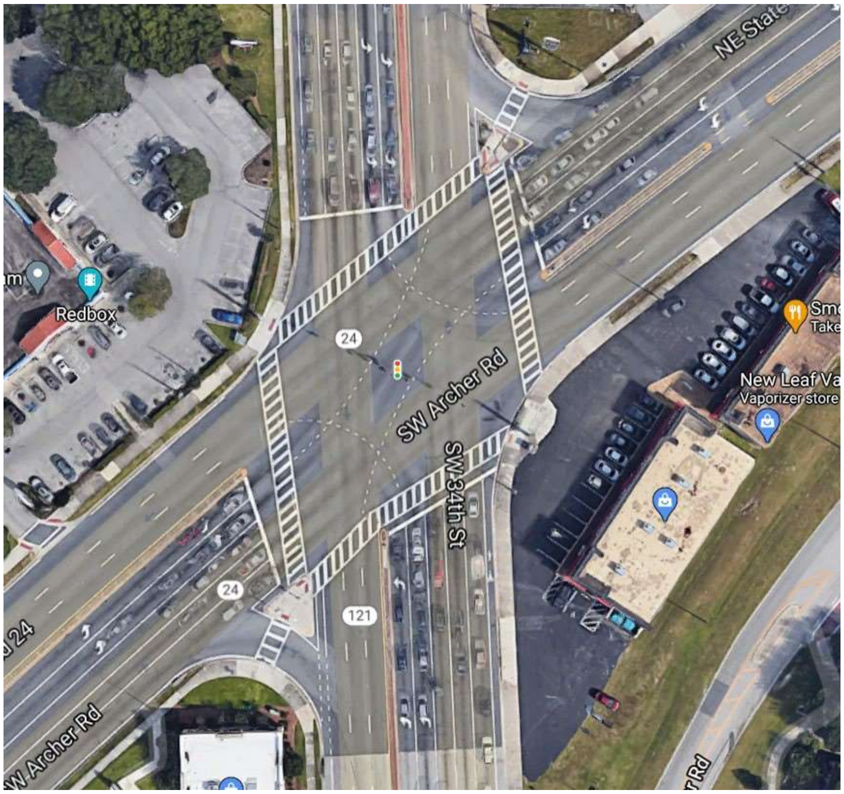


Figure A-7. Layout and lane configuration for the intersection at Archer Rd and 34th St

Table A-25. Geometric data for the intersection at Archer Rd and 34th St

Geometric Data	EB			WB			NB			SB		
	L	Th	R	L	Th	Th/R	L	Th	R	L	Th	Th/R
Total walkway width (ft)		10			10			10			10	
Crosswalk width (ft)		10			10			10			10	
Crosswalk length (ft)		190			205			175			190	
Corner radius (ft)		50			300			50			300	
Number of lanes		5			5			5			5	
Average lane width (ft)		11			11			11			11	
Number of receiving lanes(ln)		3			3			3			3	
Turn bay length (ft)	410	——	——	360	——	——	420	——	——	245	——	——
Presence of on-street parking		0			0			0			0	
Approach grade (%)		0			0			0			0	

Table A-26. Traffic characteristics for the intersection at Archer Rd and 34th St

Traffic Characteristics	EB			WB			NB			SB		
	L	Th	R	L	Th	R	L	Th	R	L	Th	R
Traffic flow rate (veh/h)	236	884	68	180	1816	516	204	584	132	192	592	180
RTOR flow rate (veh/h)	0			0			0			0		
Percentage heavy vehicles	3	3	3	3	3	3	3	3	3	3	3	3
Platoon ratio	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Upstream filtering adjustmentfactor	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Initial queue (veh)	0	0	0	0	0	0	0	0	0	0	0	0
Pedestrian flow rate (ped/h)	100			100			100			100		
Bicycle flow rate (bicycles/h)	0			0			0			0		
On-Street parking maneuver rate (veh/h)	0			0			0			0		
Local bus stopping rate (buses/h)	0			0			0			0		
Midsegment 85th percentile speed (mi/h)	45			45			45			45		
Number of right-turn islands	0			0			0			0		

Table A-27. Traffic counts for the intersection at Archer Rd and 34th St

Period	Time	EB			WB			NB			SB		
		L	T	R	L	T	R	L	T	R	L	T	R
AM peak	0730–0745	68	392	26	26	145	41	28	156	35	78	100	32
	0745–0800	67	333	20	21	165	47	32	159	38	67	90	29
	0800–0815	73	306	15	19	151	43	30	142	32	67	117	34
	0815–0830	65	319	18	21	137	39	32	124	27	68	85	24
Off-peak	1200–1215	61	216	15	46	273	77	64	119	25	64	156	45
	1215–1230	74	280	19	32	223	63	50	107	23	66	157	45
	1230–1245	72	268	19	39	251	71	53	115	24	56	127	38
	1245–1300	71	268	18	36	205	58	55	125	27	64	153	41
PM peak	1630–1645	59	221	17	45	454	129	51	146	33	48	148	45
	1645–1700	47	201	14	45	459	130	42	128	28	63	180	55
	1700–1715	58	166	9	49	396	112	53	144	31	54	189	57
	1715–1730	62	196	12	41	384	109	51	143	32	54	180	59

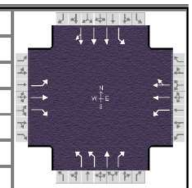
Table A-28. Signal timing data for the intersection at Archer Rd and 34th St

Phase Information	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Maximum Green (G_{max}) or Phase Split, s	35.0	90.0	25.0	90.0	35.0	45.0	45.0	60.0
Yellow Change Interval (Y), s	5.0	5.0	5.0	5.0	4.9	4.9	4.9	4.9
Red Clearance Interval (R_c), s	2.6	2.6	2.6	2.6	2.3	2.3	2.3	2.3
Minimum Green (G_{min}), s	7	4	7	4	7	12	7	12
Start-Up Lost Time (lt), s	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Extension of Effective Green (e), s	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Passage (PT), s	3.0	3.5	3.0	3.5	6.0	3.5	3.0	3.5
Recall Mode	Off	Off	Off	Off	Off	Max	Off	Max
Dual Entry	No	Yes	No	Yes	No	Yes	No	Yes
Walk ($Walk$), s	——	7.0	——	7.0	——	9.0	——	7.0
Pedestrian Clearance Time (PC), s	——	39.0	——	47.0	——	36.0	——	41.0

A.2 – HCS summary results for the signalized intersections

A.2.1 – W Univ. Ave at 34th St

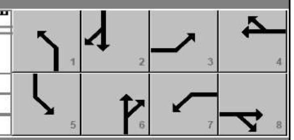
General Information				Intersection Information	
Agency				Duration, h	0.25
Analyst		Analysis Date	6/29/2020	Area Type	Other
Jurisdiction		Time Period		PHF	1.00
Urban Street	34th St	Analysis Year	2020	Analysis Period	1> 7:30
Intersection		File Name	W Uni Ave @ 34th St, Morning Peak.xus		
Project Description	WUA & 34th St				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (v), veh/h	12	368	200	104	352	76	232	568	156	108	808	164

Signal Information			
Cycle, s	125.4	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	9.5	1.7	41.2	1.4	1.9	39.7
Yellow	4.0	0.0	4.0	4.0	4.0	4.0
Red	2.0	0.0	2.0	2.0	2.0	2.0



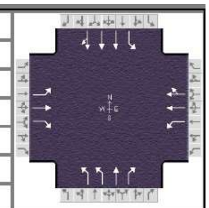
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	3	8	7	4	1	6	5	2
Case Number	2.0	3.0	2.0	4.0	2.0	3.0	2.0	4.0
Phase Duration, s	7.4	45.7	15.3	53.6	17.2	48.9	15.5	47.2
Change Period, ($Y+R_c$), s	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Max Allow Headway (MAH), s	3.6	4.7	4.6	4.7	4.6	4.6	3.6	4.6
Queue Clearance Time (g_s), s	2.8	23.2	9.3	13.2	10.3	38.4	9.5	21.2
Green Extension Time (g_e), s	0.0	5.0	0.3	5.4	0.9	4.5	0.2	10.3
Phase Call Probability	0.34	1.00	0.97	1.00	1.00	1.00	0.98	1.00
Max Out Probability	0.00	0.07	0.00	0.02	0.00	0.88	0.00	0.29

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	3	8	18	7	4	14	1	6	16	5	2	12
Adjusted Flow Rate (v), veh/h	12	368	200	104	224	204	232	568	156	108	679	293
Adjusted Saturation Flow Rate (s), veh/h/ln	1767	1856	1412	1767	1856	1623	1716	1856	1332	1767	1856	1577
Queue Service Time (g_s), s	0.8	21.2	14.1	7.3	10.7	11.2	8.3	36.4	10.9	7.5	18.9	19.2
Cycle Queue Clearance Time (g_c), s	0.8	21.2	14.1	7.3	10.7	11.2	8.3	36.4	10.9	7.5	18.9	19.2
Green Ratio (g/C)	0.01	0.32	0.32	0.07	0.38	0.38	0.09	0.34	0.34	0.08	0.33	0.33
Capacity (c), veh/h	19	587	447	131	705	617	307	634	455	134	1218	518
Volume-to-Capacity Ratio (X)	0.622	0.627	0.448	0.792	0.318	0.330	0.756	0.895	0.343	0.805	0.557	0.566
Back of Queue (Q), ft/ln (50 th percentile)	12.7	250.3	126	93.7	122.3	109.3	96	480.3	91.3	93.4	218	187.3
Back of Queue (Q), veh/ln (50 th percentile)	0.5	9.8	4.9	3.7	4.8	4.4	3.8	18.8	3.6	3.6	8.5	7.5
Queue Storage Ratio (RQ) (50 th percentile)	0.05	0.25	0.57	0.39	0.12	0.11	0.38	0.48	0.19	0.52	0.22	0.19
Uniform Delay (d_1), s/veh	61.7	36.5	34.1	57.1	27.4	27.6	55.7	39.1	30.7	57.0	34.6	34.7
Incremental Delay (d_2), s/veh	21.8	1.7	0.8	12.1	0.3	0.4	4.5	14.5	0.5	8.2	0.5	1.3
Initial Queue Delay (d_3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (d), s/veh	83.6	38.3	35.0	69.2	27.7	27.9	60.3	53.6	31.3	65.2	35.1	36.0
Level of Service (LOS)	F	D	C	E	C	C	E	D	C	E	D	D
Approach Delay, s/veh / LOS	38.1	D		35.9	D		51.6	D		38.4	D	
Intersection Delay, s/veh / LOS	41.9						D					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.59	C	2.28	B	2.12	B	2.29	B
Bicycle LOS Score / LOS	1.44	A	0.93	A	2.07	B	1.08	A

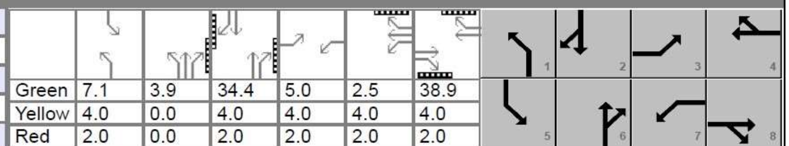
Figure A-8. Summary results for the intersection at W Univ. Ave and 34th St [AM peak]

General Information				Intersection Information	
Agency				Duration, h	0.25
Analyst		Analysis Date	6/29/2020	Area Type	Other
Jurisdiction		Time Period		PHF	1.00
Urban Street	34th St	Analysis Year	2020	Analysis Period	4> 12:45
Intersection		File Name	W Uni Ave @ 34th St, Off Peak.xus		
Project Description	WUA & 34th St				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (v), veh/h	56	284	60	164	400	88	232	484	92	80	800	164

Signal Information										
Cycle, s	121.8	Reference Phase	2							
Offset, s	0	Reference Point	End	Green	7.1	3.9	34.4	5.0	2.5	38.9
Uncoordinated	Yes	Simult. Gap E/W	On	Yellow	4.0	0.0	4.0	4.0	4.0	4.0
Force Mode	Fixed	Simult. Gap N/S	On	Red	2.0	0.0	2.0	2.0	2.0	2.0



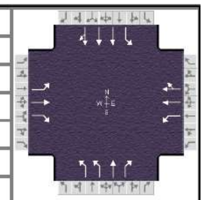
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	3	8	7	4	1	6	5	2
Case Number	2.0	3.0	2.0	4.0	2.0	3.0	2.0	4.0
Phase Duration, s	11.0	44.9	19.5	53.4	17.0	44.3	13.1	40.4
Change Period, ($Y+R_c$), s	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Max Allow Headway (*MAH*), s	3.6	4.6	4.6	4.6	4.6	4.6	3.6	4.6
Queue Clearance Time (g_s), s	5.8	17.0	13.1	14.4	10.0	31.5	7.4	21.9
Green Extension Time (g_e), s	0.1	4.2	0.5	4.2	0.9	6.9	0.1	9.0
Phase Call Probability	0.85	1.00	1.00	1.00	1.00	1.00	0.93	1.00
Max Out Probability	0.00	0.01	0.01	0.01	0.00	0.49	0.00	0.23

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	3	8	18	7	4	14	1	6	16	5	2	12
Adjusted Flow Rate (v), veh/h	56	284	60	164	257	231	232	484	92	80	675	289
Adjusted Saturation Flow Rate (s), veh/h/ln	1767	1856	1413	1767	1856	1622	1716	1856	1312	1767	1856	1557
Queue Service Time (g_s), s	3.8	15.0	3.7	11.1	12.0	12.4	8.0	29.5	6.3	5.4	19.4	19.9
Cycle Queue Clearance Time (g_c), s	3.8	15.0	3.7	11.1	12.0	12.4	8.0	29.5	6.3	5.4	19.4	19.9
Green Ratio (g/C)	0.04	0.32	0.32	0.11	0.39	0.39	0.09	0.31	0.31	0.06	0.28	0.28
Capacity (c), veh/h	73	592	451	196	722	631	310	584	413	103	1049	440
Volume-to-Capacity Ratio (X)	0.768	0.479	0.133	0.836	0.356	0.367	0.749	0.829	0.223	0.779	0.644	0.656
Back of Queue (Q), ft/ln (50 th percentile)	49.5	174.1	32.4	139.8	135.8	120.4	93	368.5	51.7	68.3	226.8	193.8
Back of Queue (Q), veh/ln (50 th percentile)	1.9	6.8	1.3	5.5	5.3	4.8	3.6	14.4	2.0	2.7	8.9	7.8
Queue Storage Ratio (RQ) (50 th percentile)	0.20	0.17	0.15	0.58	0.14	0.12	0.37	0.37	0.11	0.38	0.23	0.20
Uniform Delay (d_1), s/veh	57.8	33.3	29.5	53.1	26.4	26.5	54.1	38.7	30.8	56.6	38.3	38.5
Incremental Delay (d_2), s/veh	11.7	0.7	0.2	10.7	0.4	0.4	4.4	7.7	0.3	9.1	0.8	2.0
Initial Queue Delay (d_3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (d), s/veh	69.6	34.1	29.6	63.8	26.8	27.0	58.5	46.4	31.1	65.7	39.1	40.5
Level of Service (LOS)	E	C	C	E	C	C	E	D	C	E	D	D
Approach Delay, s/veh / LOS	38.4	D		36.1	D		48.1	D		41.5	D	
Intersection Delay, s/veh / LOS	41.7						D					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.59	C	2.28	B	2.12	B	2.30	B
Bicycle LOS Score / LOS	1.15	A	1.03	A	1.82	B	1.06	A

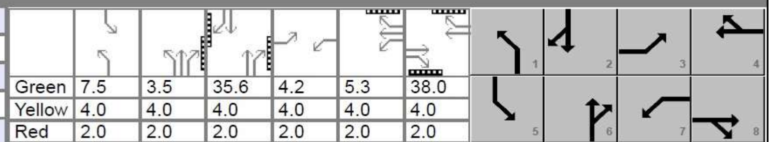
Figure A-9. Summary results for the intersection at W Univ. Ave and 34th St [Off-peak]

General Information				Intersection Information	
Agency				Duration, h	0.25
Analyst		Analysis Date	6/29/2020	Area Type	Other
Jurisdiction		Time Period		PHF	1.00
Urban Street	34th St	Analysis Year	2020	Analysis Period	2> 16:45
Intersection		File Name	W Uni Ave @ 34th St, Evening Peak.xus		
Project Description	WUA & 34th St				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	44	224	80	180	536	116	372	596	128	80	876	180

Signal Information										
Cycle, s	130.1	Reference Phase	2							
Offset, s	0	Reference Point	End	Green	7.5	3.5	35.6	4.2	5.3	38.0
Uncoordinated	Yes	Simult. Gap E/W	On	Yellow	4.0	4.0	4.0	4.0	4.0	4.0
Force Mode	Fixed	Simult. Gap N/S	On	Red	2.0	2.0	2.0	2.0	2.0	2.0



Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	3	8	7	4	1	6	5	2
Case Number	2.0	3.0	2.0	4.0	2.0	3.0	2.0	4.0
Phase Duration, s	10.2	44.0	21.5	55.2	23.0	51.1	13.5	41.6
Change Period, (*Y+R* $_c$), s	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Max Allow Headway (*MAH*), s	3.6	4.7	4.6	4.7	4.6	4.6	3.6	4.6
Queue Clearance Time (g_s), s	5.2	14.6	15.0	20.8	15.7	42.2	7.8	26.0
Green Extension Time (g_e), s	0.1	5.1	0.5	4.9	1.3	2.2	0.1	9.6
Phase Call Probability	0.80	1.00	1.00	1.00	1.00	1.00	0.94	1.00
Max Out Probability	0.00	0.02	0.03	0.04	0.13	1.00	0.00	0.43

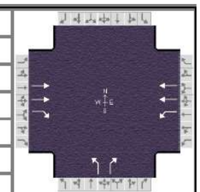
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	3	8	18	7	4	14	1	6	16	5	2	12
Adjusted Flow Rate (*v*), veh/h	44	224	80	180	346	306	372	596	128	80	742	314
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1767	1856	1400	1767	1856	1620	1716	1856	1335	1767	1856	1551
Queue Service Time (g_s), s	3.2	12.6	5.6	13.0	18.5	18.8	13.7	40.2	9.0	5.8	23.6	24.0
Cycle Queue Clearance Time (g_c), s	3.2	12.6	5.6	13.0	18.5	18.8	13.7	40.2	9.0	5.8	23.6	24.0
Green Ratio (*g/C*)	0.03	0.29	0.29	0.12	0.38	0.38	0.13	0.35	0.35	0.06	0.27	0.27
Capacity (*c*), veh/h	57	541	408	210	702	613	450	644	463	102	1016	425
Volume-to-Capacity Ratio (*X*)	0.770	0.414	0.196	0.856	0.493	0.499	0.827	0.925	0.276	0.784	0.730	0.739
Back of Queue (*Q*), ft/ln (50 th percentile)	42.8	149.1	49.6	166.9	213.8	185.8	161.1	550	75.5	73.1	281.1	240.8
Back of Queue (*Q*), veh/ln (50 th percentile)	1.7	5.8	1.9	6.5	8.4	7.4	6.3	21.5	2.9	2.9	11.0	9.6
Queue Storage Ratio (*RQ*) (50 th percentile)	0.17	0.15	0.23	0.70	0.21	0.19	0.64	0.55	0.15	0.41	0.28	0.25
Uniform Delay (d_1), s/veh	62.5	37.1	34.6	56.2	30.9	31.0	55.1	40.8	30.7	60.5	42.9	43.0
Incremental Delay (d_2), s/veh	14.8	0.6	0.3	13.0	0.6	0.8	6.3	19.5	0.4	9.4	1.8	4.5
Initial Queue Delay (d_3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (*d*), s/veh	77.3	37.7	34.9	69.2	31.5	31.8	61.4	60.4	31.1	69.9	44.7	47.5
Level of Service (LOS)	E	D	C	E	C	C	E	E	C	E	D	D
Approach Delay, s/veh / LOS	42.1	D		39.8	D		57.3	E		47.2	D	
Intersection Delay, s/veh / LOS	48.1						D					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.59	C	2.29	B	2.12	B	2.30	B
Bicycle LOS Score / LOS	1.06	A	1.17	A	2.30	B	1.11	A

Figure A-10. Summary results for the intersection at W Univ. Ave and 34th St [PM peak]

A.2.2 – W Univ. Ave at Gale Lemerand Dr

General Information				Intersection Information	
Agency				Duration, h	0.25
Analyst		Analysis Date	Mar 13, 2020	Area Type	Other
Jurisdiction		Time Period		PHF	1.00
Urban Street	West University Avenue	Analysis Year	2020	Analysis Period	1> 7:30
Intersection	Gale Lamerand	File Name	5056_W Uni Ave @ GL_Morning Peak.xus		
Project Description					



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (v), veh/h		712	232	168	748		52		60			

Signal Information										
Cycle, s	57.7	Reference Phase	2							
Offset, s	0	Reference Point	End	Green	7.4	19.2	11.5	0.0	0.0	0.0
Uncoordinated	Yes	Simult. Gap E/W	On	Yellow	3.7	3.7	3.4	0.0	0.0	0.0
Force Mode	Fixed	Simult. Gap N/S	On	Red	2.0	2.0	3.2	0.0	0.0	0.0

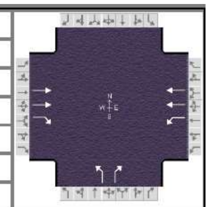
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		2	1	6		8		
Case Number		7.3	2.0	4.0		9.0		
Phase Duration, s		25.5	13.5	39.0		18.7		
Change Period, ($Y+R_c$), s		5.7	5.7	5.7		6.6		
Max Allow Headway (*MAH*), s		3.2	3.2	3.2		3.5		
Queue Clearance Time (g_s), s		11.3	7.1	8.4		3.9		
Green Extension Time (g_e), s		4.9	0.3	5.0		0.2		
Phase Call Probability		1.00	1.00	1.00		0.83		
Max Out Probability		0.00	0.00	0.00		0.00		

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement		2	12	1	6		3		18			
Adjusted Flow Rate (v), veh/h		712	232	168	748		52		60			
Adjusted Saturation Flow Rate (s), veh/h/ln		1766	1446	1767	1759		1638		1446			
Queue Service Time (g_s), s		9.3	7.1	5.1	6.4		1.5		1.9			
Cycle Queue Clearance Time (g_c), s		9.3	7.1	5.1	6.4		1.5		1.9			
Green Ratio (*g/C*)		0.34	0.34	0.13	0.58		0.21		0.21			
Capacity (c), veh/h		1210	495	236	2025		341		301			
Volume-to-Capacity Ratio (X)		0.588	0.469	0.711	0.369		0.152		0.200			
Back of Queue (Q), ft/ln (50 th percentile)		100.5	55.2	58.7	51.8		24.9		15.9			
Back of Queue (Q), veh/ln (50 th percentile)		3.9	2.2	2.3	2.0		1.0		0.6			
Queue Storage Ratio (RQ) (50 th percentile)		0.10	0.18	0.17	0.05		0.02		0.16			
Uniform Delay (d_1), s/veh		16.1	14.9	23.9	6.6		19.0		18.8			
Incremental Delay (d_2), s/veh		0.2	0.3	1.5	0.0		0.1		0.1			
Initial Queue Delay (d_3), s/veh		0.3	0.0	0.4	0.0		0.7		0.0			
Control Delay (d), s/veh		16.5	15.1	25.9	6.7		19.8		18.9			
Level of Service (LOS)		B	B	C	A		B		B			
Approach Delay, s/veh / LOS	16.2	B		10.2	B		19.3	B		0.0		
Intersection Delay, s/veh / LOS	13.6						B					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.08	B	0.66	A	2.27	B	2.63	C
Bicycle LOS Score / LOS	1.27	A	1.24	A		F		

Figure A-11. Summary results for the intersection at W Univ. Ave and Gale Lemerand Dr [AM peak]

General Information				Intersection Information	
Agency				Duration, h	0.25
Analyst		Analysis Date	Aug 7, 2020	Area Type	Other
Jurisdiction		Time Period		PHF	1.00
Urban Street	West University Avenue	Analysis Year	2020	Analysis Period	3> 12:30
Intersection	Gale Lamerand	File Name	5056_W Uni Ave @ GL_Off Peak.xus		
Project Description					



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (v), veh/h		752	96	120	708		128		80			

Signal Information			
Cycle, s	56.3	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	5.9	19.3	13.2	0.0	0.0	0.0
Yellow	3.7	3.7	3.4	0.0	0.0	0.0
Red	2.0	2.0	3.2	0.0	0.0	0.0

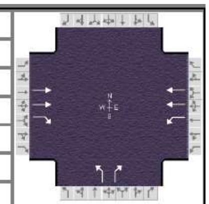
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		2	1	6		8		
Case Number		7.3	2.0	4.0		9.0		
Phase Duration, s		25.0	11.6	36.5		19.8		
Change Period, (Y+R c), s		5.7	5.7	5.7		6.6		
Max Allow Headway (MAH), s		3.1	3.2	3.1		3.4		
Queue Clearance Time (g s), s		12.0	5.7	8.4		5.6		
Green Extension Time (g e), s		4.4	0.2	4.4		0.5		
Phase Call Probability		1.00	1.00	1.00		0.96		
Max Out Probability		0.00	0.00	0.00		0.00		

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement		2	12	1	6		3		18			
Adjusted Flow Rate (v), veh/h		752	96	120	708		128		80			
Adjusted Saturation Flow Rate (s), veh/h/ln		1766	1446	1767	1759		1654		1460			
Queue Service Time (g s), s		10.0	2.6	3.7	6.4		3.6		2.5			
Cycle Queue Clearance Time (g c), s		10.0	2.6	3.7	6.4		3.6		2.5			
Green Ratio (g/C)		0.34	0.34	0.10	0.55		0.23		0.23			
Capacity (c), veh/h		1209	495	184	1928		387		342			
Volume-to-Capacity Ratio (X)		0.622	0.194	0.650	0.367		0.331		0.234			
Back of Queue (Q), ft/ln (50 th percentile)		91.5	19.7	38.7	47.9		32.8		20.1			
Back of Queue (Q), veh/ln (50 th percentile)		3.6	0.8	1.5	1.9		1.3		0.8			
Queue Storage Ratio (RQ) (50 th percentile)		0.09	0.07	0.11	0.05		0.03		0.20			
Uniform Delay (d 1), s/veh		15.5	13.1	24.3	7.2		17.9		17.5			
Incremental Delay (d 2), s/veh		0.2	0.1	1.4	0.0		0.2		0.1			
Initial Queue Delay (d 3), s/veh		0.0	0.0	0.0	0.0		0.0		0.0			
Control Delay (d), s/veh		15.7	13.1	25.7	7.3		18.1		17.6			
Level of Service (LOS)		B	B	C	A		B		B			
Approach Delay, s/veh / LOS	15.4		B	9.9		A	17.9		B	0.0		
Intersection Delay, s/veh / LOS	13.3						B					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.05	B	0.67	A	2.27	B	2.61	C
Bicycle LOS Score / LOS	1.19	A	1.17	A		F		

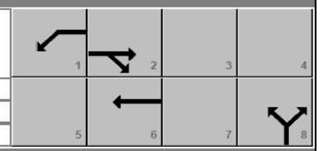
Figure A-12. Summary results for the intersection at W Univ. Ave and Gale Lemerand Dr [Off-peak]

General Information				Intersection Information	
Agency				Duration, h	0.25
Analyst		Analysis Date	Aug 7, 2020	Area Type	Other
Jurisdiction		Time Period		PHF	1.00
Urban Street	West University Avenue	Analysis Year	2020	Analysis Period	1> 16:30
Intersection	Gale Lamerand	File Name	5056_W Uni Ave @ GL_Evening Peak.xus		
Project Description					



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h		792	88	100	836		156		140			

Signal Information										
Cycle, s	59.5	Reference Phase	2							
Offset, s	0	Reference Point	End	Green	5.3	20.3	14.2	0.0	0.0	0.0
Uncoordinated	Yes	Simult. Gap E/W	On	Yellow	3.7	3.7	3.4	0.0	0.0	0.0
Force Mode	Fixed	Simult. Gap N/S	On	Red	2.0	2.0	3.2	0.0	0.0	0.0



Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		2	1	6		8		
Case Number		7.3	2.0	4.0		9.0		
Phase Duration, s		26.6	11.5	38.1		21.4		
Change Period, (*Y+R* c), s		5.7	5.7	5.7		6.6		
Max Allow Headway (*MAH*), s		3.1	3.2	3.1		3.4		
Queue Clearance Time (*g* s), s		12.9	5.2	10.3		6.6		
Green Extension Time (*g* e), s		5.0	0.1	5.1		0.7		
Phase Call Probability		1.00	1.00	1.00		0.99		
Max Out Probability		0.00	0.00	0.00		0.00		

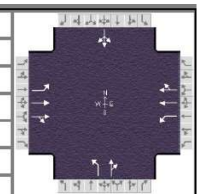
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement		2	12	1	6		3		18			
Adjusted Flow Rate (*v*), veh/h		792	88	100	836		156		140			
Adjusted Saturation Flow Rate (*s*), veh/h/ln		1766	1449	1767	1759		1660		1465			
Queue Service Time (*g* s), s		10.9	2.4	3.2	8.3		4.5		4.6			
Cycle Queue Clearance Time (*g* c), s		10.9	2.4	3.2	8.3		4.5		4.6			
Green Ratio (*g/C*)		0.35	0.35	0.09	0.54		0.25		0.25			
Capacity (*c*), veh/h		1242	509	165	1907		411		362			
Volume-to-Capacity Ratio (*X*)		0.637	0.173	0.605	0.438		0.379		0.386			
Back of Queue (*Q*), ft/ln (50 th percentile)		116.5	19	38	69.7		55.4		38.4			
Back of Queue (*Q*), veh/ln (50 th percentile)		4.6	0.7	1.5	2.7		2.2		1.5			
Queue Storage Ratio (*RQ*) (50 th percentile)		0.12	0.06	0.11	0.07		0.06		0.38			
Uniform Delay (*d* 1), s/veh		16.6	13.3	25.7	8.1		19.1		18.6			
Incremental Delay (*d* 2), s/veh		0.2	0.1	1.3	0.1		0.2		0.3			
Initial Queue Delay (*d* 3), s/veh		0.3	0.0	0.7	0.0		0.6		0.0			
Control Delay (*d*), s/veh		17.2	13.4	27.7	8.2		20.0		18.9			
Level of Service (LOS)		B	B	C	A		B		B			
Approach Delay, s/veh / LOS	16.8		B	10.3		B	19.4		B	0.0		
Intersection Delay, s/veh / LOS	14.3						B					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.07	B	0.67	A	2.28	B	2.65	C
Bicycle LOS Score / LOS	1.21	A	1.26	A		F		

Figure A-13. Summary results for the intersection at W Univ. Ave and Gale Lemerand Dr [PM peak]

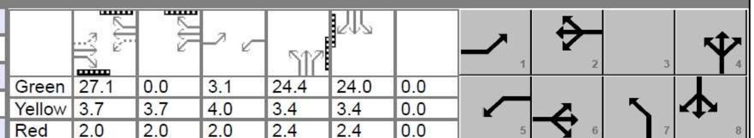
A.2.3 – W Univ. Ave at 17th St

General Information				Intersection Information	
Agency				Duration, h	0.25
Analyst		Analysis Date	Aug 7, 2020	Area Type	Other
Jurisdiction		Time Period		PHF	1.00
Urban Street	West University Ave	Analysis Year	2020	Analysis Period	2> 7:45
Intersection	WUA @ 17th St	File Name	W Uni Ave @ 17thSt_Morning Peak.xus		
Project Description					



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (v), veh/h	32	716	36	48	836	44	72	12	20	72	32	92

Signal Information										
Cycle, s	107.7	Reference Phase	2							
Offset, s	0	Reference Point	Begin	Green	27.1	0.0	3.1	24.4	24.0	0.0
Uncoordinated	Yes	Simult. Gap E/W	On	Yellow	3.7	3.7	4.0	3.4	3.4	0.0
Force Mode	Fixed	Simult. Gap N/S	On	Red	2.0	2.0	2.0	2.4	2.4	0.0



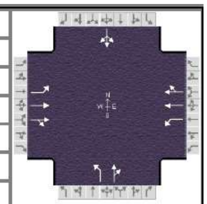
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	1	6	5	2		4		8
Case Number	1.4	4.0	1.4	4.0		10.0		12.0
Phase Duration, s	9.1	32.8	14.8	38.5		30.2		29.8
Change Period, (Y+R c), s	6.0	5.7	6.0	5.7		5.8		5.8
Max Allow Headway (MAH), s	3.7	4.6	3.7	4.6		4.2		3.4
Queue Clearance Time (g s), s	2.0	23.1	2.0	28.1		5.5		12.4
Green Extension Time (g e), s	0.2	4.0	0.2	4.7		0.3		0.4
Phase Call Probability	0.62	1.00	0.76	1.00		0.93		0.99
Max Out Probability	0.00	0.00	0.00	0.02		0.00		0.00

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	1	6	16	5	2	12	7	4	14	3	8	18
Adjusted Flow Rate (v), veh/h	32	385	367	48	480	400	72	16			172	
Adjusted Saturation Flow Rate (s), veh/h/ln	1767	1856	1767	1767	1856	1549	1767	1629			1554	
Queue Service Time (g s), s	0.0	21.1	21.1	0.0	26.1	26.1	3.5	0.8			10.4	
Cycle Queue Clearance Time (g c), s	0.0	21.1	21.1	0.0	26.1	26.1	3.5	0.8			10.4	
Green Ratio (g/C)	0.28	0.25	0.25	0.32	0.31	0.31	0.23	0.23			0.22	
Capacity (c), veh/h	124	468	445	238	566	473	401	370			346	
Volume-to-Capacity Ratio (X)	0.259	0.823	0.825	0.202	0.847	0.847	0.179	0.043			0.497	
Back of Queue (Q), ft/ln (50 th percentile)	22.2	256.9	240.4	30.7	314.3	259	39.5	8.5			101.9	
Back of Queue (Q), veh/ln (50 th percentile)	0.9	10.0	9.6	1.2	12.3	10.4	1.5	0.3			4.0	
Queue Storage Ratio (RQ) (50 th percentile)	0.17	0.63	0.60	0.24	0.37	0.31	0.30	0.03			0.55	
Uniform Delay (d 1), s/veh	50.7	38.0	38.0	44.3	35.1	35.1	33.5	32.5			36.6	
Incremental Delay (d 2), s/veh	0.8	4.4	4.7	0.3	4.4	5.3	0.2	0.0			0.4	
Initial Queue Delay (d 3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	
Control Delay (d), s/veh	51.5	42.4	42.7	44.6	39.5	40.3	33.8	32.5			37.0	
Level of Service (LOS)	D	D	D	D	D	D	C	C			D	
Approach Delay, s/veh / LOS	42.9	D		40.1	D		33.5	C		37.0	D	
Intersection Delay, s/veh / LOS	40.7						D					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.02	B	1.87	B	2.67	C	2.66	C
Bicycle LOS Score / LOS	1.13	A	1.25	A	0.63	A	0.77	A

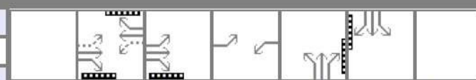
Figure A-14. Summary results for the intersection at W Univ. Ave and 17th St [AM peak]

General Information				Intersection Information		
Agency				Duration, h	0.25	
Analyst		Analysis Date	Aug 7, 2020	Area Type	Other	
Jurisdiction		Time Period		PHF	1.00	
Urban Street	West University Ave	Analysis Year	2020	Analysis Period	3> 12:30	
Intersection	WUA @ 17th St	File Name	W Uni Ave @ 17thSt_Off Peak.xus			
Project Description						

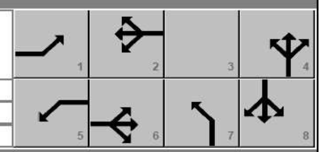


Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (v), veh/h	72	824	44	48	684	36	72	16	28	36	16	44

Signal Information				
Cycle, s	109.4	Reference Phase	2	
Offset, s	0	Reference Point	Begin	
Uncoordinated	Yes	Simult. Gap E/W	On	
Force Mode	Fixed	Simult. Gap N/S	On	



Green	27.4	4.4	3.8	25.9	24.6	0.0
Yellow	3.7	0.0	4.0	3.4	3.4	0.0
Red	2.0	0.0	2.0	2.4	2.4	0.0



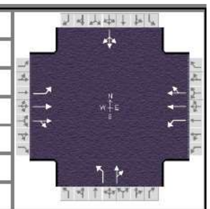
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	1	6	5	2		4		8
Case Number	1.4	4.0	1.4	4.0		10.0		12.0
Phase Duration, s	14.2	37.5	9.8	33.1		31.7		30.4
Change Period, ($Y+R_c$), s	6.0	5.7	6.0	5.7		5.8		5.8
Max Allow Headway (*MAH*), s	3.7	4.7	3.7	4.6		4.4		3.5
Queue Clearance Time (g_s), s	2.0	27.1	2.0	23.7		5.5		7.0
Green Extension Time (g_e), s	0.3	4.7	0.3	3.7		0.4		0.2
Phase Call Probability	0.89	1.00	0.77	1.00		0.96		0.92
Max Out Probability	0.00	0.02	0.00	0.00		0.00		0.00

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	1	6	16	5	2	12	7	4	14	3	8	18
Adjusted Flow Rate (v), veh/h	72	452	416	48	387	333	72	36			84	
Adjusted Saturation Flow Rate (s), veh/h/ln	1767	1856	1703	1767	1856	1593	1767	1299			1509	
Queue Service Time (g_s), s	0.0	25.0	25.1	0.0	21.6	21.7	3.5	2.4			5.0	
Cycle Queue Clearance Time (g_c), s	0.0	25.0	25.1	0.0	21.6	21.7	3.5	2.4			5.0	
Green Ratio (g/C)	0.32	0.29	0.29	0.29	0.25	0.25	0.24	0.24			0.22	
Capacity (c), veh/h	233	540	495	142	465	399	418	307			339	
Volume-to-Capacity Ratio (X)	0.310	0.838	0.839	0.338	0.832	0.834	0.172	0.117			0.248	
Back of Queue (Q), ft/ln (50 th percentile)	47.5	302.3	272.9	33.5	264.6	224.8	39.6	19.6			47.4	
Back of Queue (Q), veh/ln (50 th percentile)	1.9	11.8	10.9	1.3	10.3	9.0	1.5	0.8			1.9	
Queue Storage Ratio (RQ) (50 th percentile)	0.37	0.74	0.68	0.26	0.31	0.27	0.30	0.06			0.26	
Uniform Delay (d_1), s/veh	45.6	36.4	36.4	50.6	38.8	38.8	33.2	32.8			34.8	
Incremental Delay (d_2), s/veh	0.6	4.3	4.6	1.0	4.7	5.5	0.2	0.2			0.1	
Initial Queue Delay (d_3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	
Control Delay (d), s/veh	46.2	40.7	41.0	51.6	43.5	44.3	33.4	33.0			35.0	
Level of Service (LOS)	D	D	D	D	D	D	C	C			C	
Approach Delay, s/veh / LOS	41.3		D	44.4		D	33.3		C	35.0		C
Intersection Delay, s/veh / LOS	41.8						D					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.06	B	1.86	B	2.65	C	2.67	C
Bicycle LOS Score / LOS	1.26	A	1.12	A	0.67	A	0.63	A

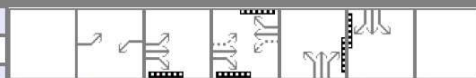
Figure A-15. Summary results for the intersection at W Univ. Ave and 17th St [Off-peak]

General Information				Intersection Information	
Agency				Duration, h	0.25
Analyst		Analysis Date	Aug 7, 2020	Area Type	Other
Jurisdiction		Time Period		PHF	1.00
Urban Street	West University Ave	Analysis Year	2020	Analysis Period	4> 17:15
Intersection	WUA @ 17th St	File Name	W Uni Ave @ 17thSt_Evening Peak.xus		
Project Description					

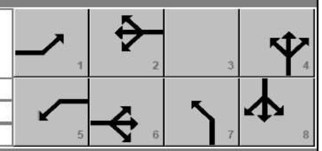


Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (v), veh/h	72	1036	56	36	800	44	112	40	64	40	20	52

Signal Information			
Cycle, s	123.6	Reference Phase	2
Offset, s	0	Reference Point	Begin
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On



Green	3.5	1.2	45.9	25.6	24.1	0.0
Yellow	4.0	0.0	3.7	3.4	3.4	0.0
Red	2.0	0.0	2.0	2.4	2.4	0.0



Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	1	6	5	2		4		8
Case Number	1.1	4.0	1.1	4.0		10.0		12.0
Phase Duration, s	10.8	52.8	9.5	51.6		31.4		29.9
Change Period, (Y+R c), s	6.0	5.7	6.0	5.7		5.8		5.8
Max Allow Headway (MAH), s	3.7	4.6	3.7	4.6		4.5		3.3
Queue Clearance Time (g s), s	5.1	37.2	3.5	27.4		8.8		6.1
Green Extension Time (g e), s	0.1	9.9	0.1	12.4		0.8		0.1
Phase Call Probability	0.92	1.00	0.71	1.00		1.00		0.90
Max Out Probability	0.00	0.54	0.00	0.34		0.00		0.00

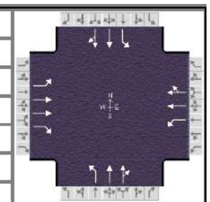
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	1	6	16	5	2	12	7	4	14	3	8	18
Adjusted Flow Rate (v), veh/h	72	585	507	36	456	388	112	88			68	
Adjusted Saturation Flow Rate (s), veh/h/ln	1767	1856	1609	1767	1856	1575	1767	1350			1707	
Queue Service Time (g s), s	3.1	35.2	35.2	1.5	25.4	25.4	6.6	6.8			4.1	
Cycle Queue Clearance Time (g c), s	3.1	35.2	35.2	1.5	25.4	25.4	6.6	6.8			4.1	
Green Ratio (g/C)	0.41	0.38	0.38	0.40	0.37	0.37	0.21	0.21			0.19	
Capacity (c), veh/h	234	707	613	150	689	585	366	279			332	
Volume-to-Capacity Ratio (X)	0.307	0.827	0.827	0.240	0.663	0.663	0.306	0.315			0.205	
Back of Queue (Q), ft/ln (50 th percentile)	34.2	433.4	371.1	17.3	298.2	248.9	75.8	60			45.1	
Back of Queue (Q), veh/ln (50 th percentile)	1.3	16.9	14.8	0.7	11.6	10.0	3.0	2.3			1.8	
Queue Storage Ratio (RQ) (50 th percentile)	0.26	1.06	0.93	0.13	0.35	0.30	0.58	0.19			0.24	
Uniform Delay (d 1), s/veh	25.4	34.6	34.6	28.4	32.4	32.4	41.5	41.6			41.7	
Incremental Delay (d 2), s/veh	0.5	6.4	7.3	0.6	1.7	2.0	0.5	0.6			0.1	
Initial Queue Delay (d 3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	
Control Delay (d), s/veh	25.9	40.9	41.9	29.0	34.1	34.4	42.0	42.2			41.9	
Level of Service (LOS)	C	D	D	C	C	C	D	D			D	
Approach Delay, s/veh / LOS	40.4	D		34.1	C		42.1	D		41.9	D	
Intersection Delay, s/veh / LOS	38.2						D					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.07	B	1.91	B	2.73	C	2.74	C
Bicycle LOS Score / LOS	1.45	A	1.21	A	0.82	A	0.60	A

Figure A-16. Summary results for the intersection at W Univ. Ave and 17[th] St [PM peak]

A.2.4 – W Univ. Ave at 13th St

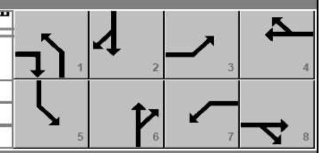
General Information				Intersection Information	
Agency	UFTI			Duration, h	0.25
Analyst	Muhammad Saif Uddin	Analysis Date	Aug 7, 2020	Area Type	CBD
Jurisdiction		Time Period		PHF	1.00
Urban Street	13th St	Analysis Year	2020	Analysis Period	1> 7:30
Intersection	W Univ Ave @ 13th St	File Name	W Uni Ave @ 13th St, AM Peak.xus		
Project Description					



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (v), veh/h	68	436	188	112	528	116	96	680	204	72	1052	216

Signal Information			
Cycle, s	129.5	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	7.3	2.3	54.8	7.0	4.1	31.0
Yellow	3.8	0.0	3.8	3.7	0.0	3.7
Red	2.0	0.0	2.0	2.0	0.0	2.0



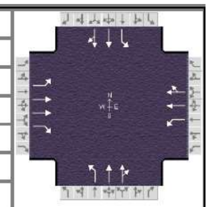
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	3	8	7	4	1	6	5	2
Case Number	2.0	3.0	2.0	4.0	2.0	4.0	2.0	4.0
Phase Duration, s	12.7	36.7	16.7	40.8	15.4	63.0	13.1	60.6
Change Period, (Y+R c), s	5.7	5.7	5.7	5.7	5.8	5.8	5.8	5.8
Max Allow Headway (MAH), s	4.2	4.8	4.2	4.8	4.2	4.7	3.7	4.7
Queue Clearance Time (g s), s	7.5	18.2	11.0	27.7	9.7	30.3	7.8	53.6
Green Extension Time (g e), s	0.1	7.7	0.3	6.5	0.3	17.7	0.1	1.2
Phase Call Probability	0.91	1.00	0.98	1.00	0.97	1.00	0.93	1.00
Max Out Probability	0.00	0.10	0.00	0.27	0.00	0.32	0.00	1.00

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	3	8	18	7	4	14	1	6	16	5	2	12
Adjusted Flow Rate (v), veh/h	68	436	188	112	350	294	96	469	415	72	675	593
Adjusted Saturation Flow Rate (s), veh/h/ln	1590	1590	1221	1590	1670	1372	1590	1670	1479	1590	1670	1451
Queue Service Time (g s), s	5.5	15.7	16.2	9.0	25.1	25.7	7.7	28.2	28.3	5.8	50.6	51.6
Cycle Queue Clearance Time (g c), s	5.5	15.7	16.2	9.0	25.1	25.7	7.7	28.2	28.3	5.8	50.6	51.6
Green Ratio (g/C)	0.05	0.24	0.31	0.09	0.27	0.27	0.07	0.44	0.44	0.06	0.42	0.42
Capacity (c), veh/h	86	761	397	136	452	371	118	737	653	90	707	615
Volume-to-Capacity Ratio (X)	0.795	0.573	0.474	0.826	0.775	0.791	0.810	0.636	0.636	0.800	0.954	0.965
Back of Queue (Q), ft/ln (50 th percentile)	65.9	160.7	126.9	104	282.4	236.9	89.9	293.3	255	67.2	634.4	566.1
Back of Queue (Q), veh/ln (50 th percentile)	2.6	6.3	5.0	4.1	11.0	9.5	3.5	11.5	10.2	2.6	24.8	22.6
Queue Storage Ratio (RQ) (50 th percentile)	0.15	0.23	0.53	0.43	0.47	0.40	0.29	0.54	0.48	0.14	1.08	0.98
Uniform Delay (d 1), s/veh	60.6	43.4	36.1	58.3	43.6	43.8	59.0	28.1	28.1	60.4	36.1	36.4
Incremental Delay (d 2), s/veh	15.1	0.8	1.1	11.8	5.4	7.3	12.3	1.2	1.4	11.4	23.2	27.7
Initial Queue Delay (d 3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (d), s/veh	75.7	44.3	37.1	70.1	49.0	51.2	71.3	29.3	29.5	71.8	59.3	64.1
Level of Service (LOS)	E	D	D	E	D	D	E	C	C	E	E	E
Approach Delay, s/veh / LOS	45.4		D	53.0		D	33.5		C	62.1		E
Intersection Delay, s/veh / LOS	49.8						D					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.77	C	2.75	C	2.60	C	2.72	C
Bicycle LOS Score / LOS	1.06	A	1.11	A	1.30	A	1.59	B

Figure A-17. Summary results for the intersection at W Univ. Ave and 13th St [AM peak]

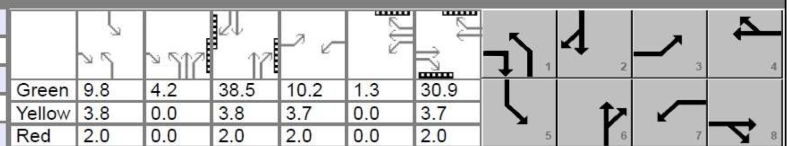
General Information				Intersection Information	
Agency	UFTI			Duration, h	0.25
Analyst	Muhammad Saif Uddin	Analysis Date	Aug 7, 2020	Area Type	CBD
Jurisdiction		Time Period		PHF	1.00
Urban Street	13th St	Analysis Year	2020	Analysis Period	4> 12:45
Intersection	W Univ Ave @ 13th St	File Name	W Uni Ave @ 13th St, Off Peak.xus		
Project Description					



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (v), veh/h	112	408	176	128	380	84	160	712	212	108	436	88

Signal Information			
Cycle, s	118.0	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	9.8	4.2	38.5	10.2	1.3	30.9
Yellow	3.8	0.0	3.8	3.7	0.0	3.7
Red	2.0	0.0	2.0	2.0	0.0	2.0



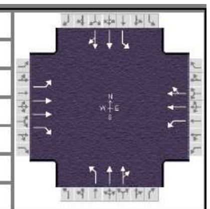
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	3	8	7	4	1	6	5	2
Case Number	2.0	3.0	2.0	4.0	2.0	4.0	2.0	4.0
Phase Duration, s	15.9	36.6	17.2	37.9	19.8	48.6	15.6	44.3
Change Period, (Y+R c), s	5.7	5.7	5.7	5.7	5.8	5.8	5.8	5.8
Max Allow Headway (MAH), s	4.2	4.8	4.2	4.8	4.2	4.7	3.7	4.7
Queue Clearance Time (g s), s	10.2	14.8	11.3	17.9	13.6	33.4	9.9	19.7
Green Extension Time (g e), s	0.3	6.2	0.3	6.1	0.4	9.3	0.2	9.3
Phase Call Probability	0.97	1.00	0.98	1.00	0.99	1.00	0.97	1.00
Max Out Probability	0.00	0.03	0.00	0.04	0.00	0.07	0.00	0.08

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	3	8	18	7	4	14	1	6	16	5	2	12
Adjusted Flow Rate (v), veh/h	112	408	176	128	249	215	160	491	433	108	294	230
Adjusted Saturation Flow Rate (s), veh/h/ln	1590	1590	1237	1590	1670	1377	1590	1670	1470	1590	1670	1266
Queue Service Time (g s), s	8.2	12.8	12.1	9.3	15.0	15.9	11.6	31.4	31.4	7.9	17.0	17.7
Cycle Queue Clearance Time (g c), s	8.2	12.8	12.1	9.3	15.0	15.9	11.6	31.4	31.4	7.9	17.0	17.7
Green Ratio (g/C)	0.09	0.26	0.38	0.10	0.27	0.27	0.12	0.36	0.36	0.08	0.33	0.33
Capacity (c), veh/h	137	833	491	155	456	376	189	606	533	132	546	414
Volume-to-Capacity Ratio (X)	0.815	0.490	0.358	0.827	0.546	0.572	0.846	0.812	0.812	0.816	0.539	0.556
Back of Queue (Q), ft/ln (50 th percentile)	94.2	129.4	93.2	106.8	161	137.9	131.7	335	289.6	88.9	179	138.9
Back of Queue (Q), veh/ln (50 th percentile)	3.7	5.1	3.6	4.2	6.3	5.5	5.1	13.1	11.6	3.5	7.0	5.6
Queue Storage Ratio (RQ) (50 th percentile)	0.21	0.19	0.39	0.45	0.27	0.23	0.42	0.61	0.54	0.19	0.30	0.24
Uniform Delay (d 1), s/veh	53.0	36.9	26.4	52.3	36.7	37.0	50.9	34.0	34.0	53.2	32.5	32.7
Incremental Delay (d 2), s/veh	11.0	0.5	0.5	10.6	1.2	1.7	9.9	3.2	3.6	8.8	1.0	1.4
Initial Queue Delay (d 3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (d), s/veh	64.0	37.4	26.9	62.9	37.9	38.6	60.8	37.2	37.6	62.0	33.5	34.1
Level of Service (LOS)	E	D	C	E	D	D	E	D	D	E	C	C
Approach Delay, s/veh / LOS	39.0	D		43.6	D		40.9	D		38.6	D	
Intersection Delay, s/veh / LOS	40.5						D					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.67	C	2.61	C	2.57	C	2.68	C
Bicycle LOS Score / LOS	1.06	A	0.98	A	1.38	A	1.01	A

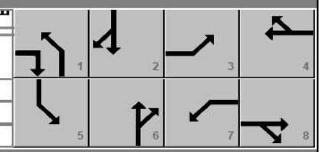
Figure A-18. Summary results for the intersection at W Univ. Ave and 13th St [Off-peak]

General Information				Intersection Information	
Agency	UFTI			Duration, h	0.25
Analyst	Muhammad Saif Uddin	Analysis Date	Aug 7, 2020	Area Type	CBD
Jurisdiction		Time Period		PHF	1.00
Urban Street	13th St	Analysis Year	2020	Analysis Period	4> 17:15
Intersection	W Univ Ave @ 13th St	File Name	W Uni Ave @ 13th St_Evening Peak.xus		
Project Description					



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (v), veh/h	184	504	216	116	372	84	144	1100	328	76	488	100

Signal Information										
Cycle, s	152.9	Reference Phase	2							
Offset, s	0	Reference Point	End	Green	9.0	1.2	63.0	13.1	0.8	31.2
Uncoordinated	Yes	Simult. Gap E/W	On	Yellow	3.8	3.8	3.8	3.7	3.7	3.7
Force Mode	Fixed	Simult. Gap N/S	On	Red	2.0	2.0	2.0	2.0	2.0	2.0



Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	3	8	7	4	1	6	5	2
Case Number	2.0	3.0	2.0	4.0	2.0	4.0	2.0	4.0
Phase Duration, s	25.4	43.5	18.8	36.9	21.8	75.8	14.8	68.8
Change Period, (Y+R c), s	5.7	5.7	5.7	5.7	5.8	5.8	5.8	5.8
Max Allow Headway (MAH), s	4.2	4.8	4.2	4.8	4.2	4.7	3.7	4.7
Queue Clearance Time (g s), s	19.4	23.7	13.0	24.7	15.6	71.6	9.2	23.0
Green Extension Time (g e), s	0.3	6.6	0.2	6.5	0.4	0.0	0.1	15.1
Phase Call Probability	1.00	1.00	0.99	1.00	1.00	1.00	0.96	1.00
Max Out Probability	0.37	0.14	0.00	0.16	0.00	1.00	0.00	0.36

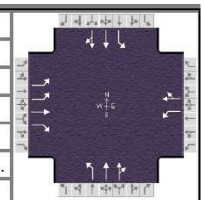
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	3	8	18	7	4	14	1	6	16	5	2	12
Adjusted Flow Rate (v), veh/h	184	504	216	116	247	209	144	745	683	76	310	278
Adjusted Saturation Flow Rate (s), veh/h/ln	1590	1590	1237	1590	1670	1325	1590	1670	1496	1590	1670	1469
Queue Service Time (g s), s	17.4	21.7	21.0	11.0	21.2	22.7	13.6	66.8	69.6	7.2	20.5	21.0
Cycle Queue Clearance Time (g c), s	17.4	21.7	21.0	11.0	21.2	22.7	13.6	66.8	69.6	7.2	20.5	21.0
Green Ratio (g/C)	0.13	0.25	0.35	0.09	0.20	0.20	0.10	0.46	0.46	0.06	0.41	0.41
Capacity (c), veh/h	205	785	453	137	341	271	166	765	685	93	688	605
Volume-to-Capacity Ratio (X)	0.898	0.642	0.477	0.848	0.726	0.771	0.867	0.974	0.997	0.814	0.451	0.459
Back of Queue (Q), ft/ln (50 th percentile)	220.4	226.7	168.1	128	238.6	203.5	157.4	836.9	793.1	83.7	217.9	191.9
Back of Queue (Q), veh/ln (50 th percentile)	8.6	8.9	6.6	5.0	9.3	8.1	6.1	32.7	31.7	3.3	8.5	7.7
Queue Storage Ratio (RQ) (50 th percentile)	0.49	0.33	0.70	0.53	0.39	0.34	0.51	1.54	1.49	0.18	0.37	0.33
Uniform Delay (d 1), s/veh	65.6	51.5	39.0	68.9	56.8	57.5	67.4	40.6	41.4	71.1	32.4	32.6
Incremental Delay (d 2), s/veh	26.5	1.3	0.9	13.3	3.6	6.6	12.6	26.3	33.6	11.8	0.6	0.7
Initial Queue Delay (d 3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (d), s/veh	92.1	52.8	39.9	82.2	60.4	64.0	80.0	66.9	75.0	83.0	33.0	33.2
Level of Service (LOS)	F	D	D	F	E	E	F	E	E	F	C	C
Approach Delay, s/veh / LOS	57.7	E		66.2	E		71.6	E		38.8	D	
Intersection Delay, s/veh / LOS	61.5						E					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.79	C	2.72	C	2.61	C	2.73	C
Bicycle LOS Score / LOS	1.23	A	0.96	A	1.78	B	1.04	A

Figure A-19. Summary results for the intersection at W Univ. Ave and 13th St [PM peak]

A.2.5 – SW 8th Ave at 13th St

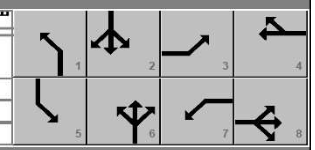
General Information				Intersection Information	
Agency				Duration, h	0.25
Analyst		Analysis Date	6/29/2020	Area Type	Other
Jurisdiction		Time Period		PHF	1.00
Urban Street	SW 13th St	Analysis Year	2020	Analysis Period	2> 7:45
Intersection	13th & Museum Rd	File Name	5960_SW 13th @ 8th Ave (Museum Rd)_Morning…		
Project Description					



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (v), veh/h	304	148	16	88	148	16	64	588	44	64	1172	132

Signal Information			
Cycle, s	132.6	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	4.5	59.6	1.4	8.3	3.8	24.2
Yellow	3.9	3.9	3.9	3.4	0.0	3.4
Red	2.0	2.0	2.0	3.2	0.0	3.2



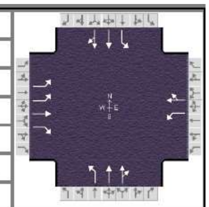
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	3	8	7	4	1	6	5	2
Case Number	1.1	3.0	2.0	4.0	1.2	4.0	1.3	4.0
Phase Duration, s	18.7	34.5	14.9	30.8	10.4	75.9	7.3	72.8
Change Period, (Y+R c), s	6.5	6.6	6.6	6.6	5.9	5.9	5.9	5.9
Max Allow Headway (MAH), s	3.7	4.1	3.7	4.1	3.7	4.6	4.6	4.6
Queue Clearance Time (g s), s	11.4	11.1	8.5	12.9	4.5	15.2	2.0	39.4
Green Extension Time (g e), s	0.8	1.1	0.2	1.1	0.1	3.3	0.3	8.3
Phase Call Probability	1.00	1.00	0.96	1.00	0.91	1.00	0.91	1.00
Max Out Probability	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.16

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	3	8	18	7	4	14	1	6	16	5	2	12
Adjusted Flow Rate (v), veh/h	304	148	16	88	164		64	322	310	64	669	635
Adjusted Saturation Flow Rate (s), veh/h/ln	1716	1856	1449	1767	1791		1767	1856	1780	1767	1856	1753
Queue Service Time (g s), s	9.4	9.1	1.2	6.5	10.9		2.5	13.1	13.2	0.0	37.1	37.4
Cycle Queue Clearance Time (g c), s	9.4	9.1	1.2	6.5	10.9		2.5	13.1	13.2	0.0	37.1	37.4
Green Ratio (g/C)	0.27	0.21	0.21	0.06	0.18		0.50	0.53	0.53	0.44	0.50	0.50
Capacity (c), veh/h	666	391	305	111	326		184	979	940	398	935	883
Volume-to-Capacity Ratio (X)	0.456	0.379	0.052	0.793	0.502		0.347	0.329	0.330	0.161	0.715	0.719
Back of Queue (Q), ft/ln (50 th percentile)	102.6	109.6	11	82.2	128.6		27.6	150.9	142.5	33.1	442.9	413.7
Back of Queue (Q), veh/ln (50 th percentile)	4.0	4.3	0.4	3.2	5.0		1.1	5.9	5.7	1.3	17.3	16.5
Queue Storage Ratio (RQ) (50 th percentile)	0.24	0.11	0.05	0.46	0.13		0.14	0.15	0.15	0.14	0.44	0.42
Uniform Delay (d 1), s/veh	38.9	44.9	41.8	61.3	48.8		24.2	17.9	17.9	24.0	25.5	25.6
Incremental Delay (d 2), s/veh	0.4	0.6	0.1	9.1	1.2		0.8	0.9	0.9	0.1	4.7	5.0
Initial Queue Delay (d 3), s/veh	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (d), s/veh	39.2	45.5	41.9	70.4	50.0		25.1	18.8	18.9	24.1	30.2	30.6
Level of Service (LOS)	D	D	D	E	D		C	B	B	C	C	C
Approach Delay, s/veh / LOS	41.3	D		57.1	E		19.4	B		30.1	C	
Intersection Delay, s/veh / LOS	31.8						C					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.31	B	2.31	B	1.96	B	2.27	B
Bicycle LOS Score / LOS	1.26	A	0.90	A	1.06	A	1.62	B

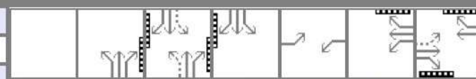
Figure A-20. Summary results for the intersection at SW 8th Ave and 13th St [AM peak]

General Information				Intersection Information	
Agency				Duration, h	0.25
Analyst		Analysis Date	6/29/2020	Area Type	Other
Jurisdiction		Time Period		PHF	1.00
Urban Street	SW 13th St	Analysis Year	2020	Analysis Period	3> 12:30
Intersection	13th & Museum Rd	File Name	5960_SW 13th @ 8th Ave (Museum Rd)_Off Pea...		
Project Description					

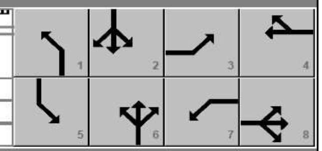


Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (v), veh/h	148	164	20	76	164	20	68	540	44	68	920	104

Signal Information			
Cycle, s	130.4	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On



Green	4.6	59.5	1.7	7.0	0.3	26.5
Yellow	3.9	3.9	3.9	3.4	0.0	3.4
Red	2.0	2.0	2.0	3.1	0.0	3.2



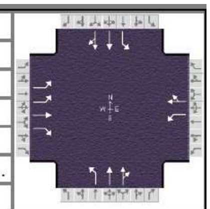
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	3	8	7	4	1	6	5	2
Case Number	1.1	3.0	2.0	4.0	1.2	4.0	1.3	4.0
Phase Duration, s	13.5	33.1	13.8	33.4	10.5	75.9	7.6	73.0
Change Period, ($Y+R_c$), s	6.5	6.6	6.6	6.6	5.9	5.9	5.9	5.9
Max Allow Headway (*MAH*), s	3.7	4.1	3.7	4.1	3.7	4.6	4.6	4.6
Queue Clearance Time (g_s), s	6.4	12.1	7.5	13.9	4.6	13.6	2.0	27.1
Green Extension Time (g_e), s	0.4	1.3	0.1	1.3	0.1	3.0	0.3	6.4
Phase Call Probability	1.00	1.00	0.94	1.00	0.91	1.00	0.91	1.00
Max Out Probability	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.01

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	3	8	18	7	4	14	1	6	16	5	2	12
Adjusted Flow Rate (v), veh/h	148	164	20	76	184		68	298	286	68	527	497
Adjusted Saturation Flow Rate (s), veh/h/ln	1716	1856	1445	1767	1788		1767	1856	1776	1767	1856	1753
Queue Service Time (g_s), s	4.4	10.1	1.5	5.5	11.9		2.6	11.5	11.6	0.0	25.1	25.1
Cycle Queue Clearance Time (g_c), s	4.4	10.1	1.5	5.5	11.9		2.6	11.5	11.6	0.0	25.1	25.1
Green Ratio (*g/C*)	0.26	0.20	0.20	0.06	0.21		0.51	0.54	0.54	0.45	0.51	0.51
Capacity (c), veh/h	531	378	294	97	368		261	996	953	434	955	902
Volume-to-Capacity Ratio (X)	0.279	0.434	0.068	0.781	0.500		0.260	0.299	0.300	0.157	0.551	0.552
Back of Queue (Q), ft/ln (50 th percentile)	47.9	121.7	13.7	70.4	138.6		27.8	131.3	123.9	33	291.9	270.1
Back of Queue (Q), veh/ln (50 th percentile)	1.9	4.8	0.5	2.7	5.4		1.1	5.1	5.0	1.3	11.4	10.8
Queue Storage Ratio (*RQ*) (50 th percentile)	0.11	0.12	0.07	0.39	0.14		0.14	0.13	0.13	0.14	0.29	0.28
Uniform Delay (d_1), s/veh	38.4	45.4	41.9	60.8	45.8		19.7	16.7	16.7	21.9	21.4	21.4
Incremental Delay (d_2), s/veh	0.2	0.8	0.1	9.6	1.1		0.4	0.8	0.8	0.1	2.3	2.4
Initial Queue Delay (d_3), s/veh	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (d), s/veh	38.6	46.2	42.0	70.4	46.9		20.1	17.4	17.5	22.0	23.7	23.9
Level of Service (LOS)	D	D	D	E	D		C	B	B	C	C	C
Approach Delay, s/veh / LOS	42.5	D		53.8	D		17.7	B		23.7	C	
Intersection Delay, s/veh / LOS	28.1						C					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.31	B	2.31	B	1.96	B	2.27	B
Bicycle LOS Score / LOS	1.04	A	0.92	A	1.03	A	1.39	A

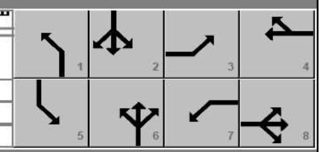
Figure A-21. Summary results for the intersection at SW 8th Ave and 13th St [Off-peak]

General Information				Intersection Information	
Agency				Duration, h	0.25
Analyst		Analysis Date	6/29/2020	Area Type	Other
Jurisdiction		Time Period		PHF	1.00
Urban Street	SW 13th St	Analysis Year	2020	Analysis Period	3> 17:00
Intersection	13th & Museum Rd	File Name	5960_SW 13th @ 8th Ave (Museum Rd)_Evening...		
Project Description					



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (v), veh/h	96	64	8	64	64	8	64	616	56	64	1220	136

Signal Information										
Cycle, s	127.5	Reference Phase	2							
Offset, s	0	Reference Point	End	Green	4.5	59.6	1.2	6.0	0.7	24.6
Uncoordinated	Yes	Simult. Gap E/W	On	Yellow	3.9	3.9	3.9	3.4	0.0	3.4
Force Mode	Fixed	Simult. Gap N/S	On	Red	2.0	2.0	2.0	3.2	0.0	3.2



Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	3	8	7	4	1	6	5	2
Case Number	1.1	3.0	2.0	4.0	1.2	4.0	1.3	4.0
Phase Duration, s	13.3	31.8	12.6	31.2	10.4	75.9	7.1	72.7
Change Period, ($Y+R_c$), s	6.5	6.6	6.6	6.6	5.9	5.9	5.9	5.9
Max Allow Headway (*MAH*), s	3.7	4.1	3.7	4.1	3.7	4.6	4.6	4.6
Queue Clearance Time (g_s), s	4.8	5.7	6.6	6.3	4.3	15.1	2.0	38.7
Green Extension Time (g_e), s	0.2	0.5	0.1	0.5	0.1	3.5	0.3	8.9
Phase Call Probability	0.97	1.00	0.90	1.00	0.90	1.00	0.90	1.00
Max Out Probability	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.17

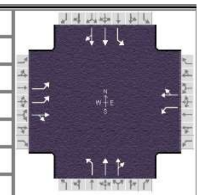
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	3	8	18	7	4	14	1	6	16	5	2	12
Adjusted Flow Rate (v), veh/h	96	64	8	64	72		64	343	329	64	695	661
Adjusted Saturation Flow Rate (s), veh/h/ln	1716	1856	1442	1767	1785		1767	1856	1769	1767	1856	1754
Queue Service Time (g_s), s	2.8	3.7	0.6	4.6	4.3		2.3	13.1	13.1	0.0	36.3	36.7
Cycle Queue Clearance Time (g_c), s	2.8	3.7	0.6	4.6	4.3		2.3	13.1	13.1	0.0	36.3	36.7
Green Ratio (*g/C*)	0.25	0.20	0.20	0.05	0.19		0.52	0.55	0.55	0.46	0.52	0.52
Capacity (c), veh/h	714	367	286	83	344		190	1019	972	401	972	919
Volume-to-Capacity Ratio (X)	0.134	0.174	0.028	0.772	0.209		0.337	0.337	0.338	0.160	0.715	0.720
Back of Queue (Q), ft/ln (50 th percentile)	30.2	43.9	5.3	58.7	50.1		25	147.4	138.3	30.7	428.6	402.6
Back of Queue (Q), veh/ln (50 th percentile)	1.2	1.7	0.2	2.3	2.0		1.0	5.8	5.5	1.2	16.7	16.1
Queue Storage Ratio (RQ) (50 th percentile)	0.07	0.04	0.03	0.33	0.05		0.13	0.15	0.14	0.13	0.43	0.41
Uniform Delay (d_1), s/veh	37.4	42.5	41.2	60.1	43.3		22.4	15.9	15.9	21.8	23.1	23.2
Incremental Delay (d_2), s/veh	0.1	0.2	0.0	10.7	0.3		0.8	0.9	0.9	0.1	4.5	4.8
Initial Queue Delay (d_3), s/veh	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (d), s/veh	37.4	42.7	41.3	70.7	43.6		23.1	16.8	16.9	21.9	27.6	28.1
Level of Service (LOS)	D	D	D	E	D		C	B	B	C	C	C
Approach Delay, s/veh / LOS	39.6	D		56.4	E		17.4	B		27.6	C	
Intersection Delay, s/veh / LOS	26.9						C					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.31	B	2.31	B	1.96	B	2.26	B
Bicycle LOS Score / LOS	0.76	A	0.71	A	1.09	A	1.66	B

Figure A-22. Summary results for the intersection at SW 8th Ave and 13th St [PM peak]

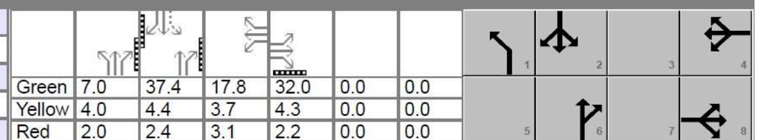
A.2.6 – Archer Rd at 13th St

General Information				Intersection Information	
Agency				Duration, h	0.25
Analyst		Analysis Date	7/13/2020	Area Type	Other
Jurisdiction		Time Period		PHF	1.00
Urban Street	Archer Rd	Analysis Year	2020	Analysis Period	2> 7:45
Intersection	Archer Rd & 13th St	File Name	7360_Archer Rd @ 13th St_Morning Peak.xus		
Project Description					



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (v), veh/h	560	100	20	64	212	24	80	684	36	28	944	56

Signal Information			
Cycle, s	120.3	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On



Green	7.0	37.4	17.8	32.0	0.0	0.0
Yellow	4.0	4.4	3.7	4.3	0.0	0.0
Red	2.0	2.4	3.1	2.2	0.0	0.0

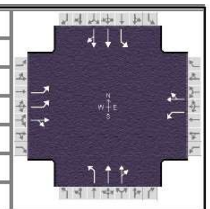
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		8		4	1	6		2
Case Number		10.0		10.0	2.0	4.0		6.3
Phase Duration, s		38.5		24.6	13.0	57.2		44.2
Change Period, ($Y+R_c$), s		6.5		6.8	6.0	6.8		6.8
Max Allow Headway (*MAH*), s		3.2		3.1	3.2	3.2		3.2
Queue Clearance Time (g_s), s		19.3		17.3	7.4	19.1		33.3
Green Extension Time (g_e), s		1.7		0.5	0.1	4.1		4.0
Phase Call Probability		1.00		1.00	0.93	1.00		1.00
Max Out Probability		0.00		0.00	0.00	0.00		0.02

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	3	8	18	7	4	14	1	6	16	5	2	12
Adjusted Flow Rate (v), veh/h	560	120		64	236		80	364	356	28	508	492
Adjusted Saturation Flow Rate (s), veh/h/ln	1716	1781		1767	1822		1767	1856	1809	719	1856	1798
Queue Service Time (g_s), s	17.3	6.4		3.9	15.3		5.4	17.1	17.1	3.5	31.3	31.3
Cycle Queue Clearance Time (g_c), s	17.3	6.4		3.9	15.3		5.4	17.1	17.1	7.5	31.3	31.3
Green Ratio (g/C)	0.27	0.27		0.15	0.15		0.06	0.42	0.42	0.31	0.31	0.31
Capacity (c), veh/h	912	473		262	270		103	778	759	260	578	560
Volume-to-Capacity Ratio (X)	0.614	0.254		0.244	0.874		0.779	0.468	0.469	0.108	0.879	0.879
Back of Queue (Q), ft/ln (50 th percentile)	186.6	71.8		43.9	187.5		64.9	192.9	183.9	16	375.8	356
Back of Queue (Q), veh/ln (50 th percentile)	7.3	2.8		1.7	7.3		2.5	7.5	7.4	0.6	14.7	14.2
Queue Storage Ratio (RQ) (50 th percentile)	0.19	0.17		0.17	0.72		0.38	0.19	0.19	0.16	0.38	0.36
Uniform Delay (d_1), s/veh	38.8	34.8		45.4	50.2		56.0	25.3	25.3	32.6	39.3	39.3
Incremental Delay (d_2), s/veh	0.3	0.1		0.2	5.0		4.7	0.2	0.2	0.1	3.6	3.7
Initial Queue Delay (d_3), s/veh	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (d), s/veh	39.1	34.9		45.5	55.2		60.7	25.4	25.5	32.7	43.0	43.1
Level of Service (LOS)	D	C		D	E		E	C	C	C	D	D
Approach Delay, s/veh / LOS	38.3	D		53.2	D		29.0	C		42.7	D	
Intersection Delay, s/veh / LOS	38.9						D					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.33	B	2.30	B	1.92	B	2.12	B
Bicycle LOS Score / LOS	1.61	B	0.98	A	1.15	A	1.34	A

Figure A-23. Summary results for the intersection at Archer Rd and 13th St [AM peak]

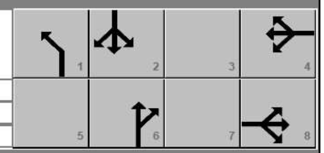
General Information				Intersection Information	
Agency				Duration, h	0.25
Analyst		Analysis Date	7/13/2020	Area Type	Other
Jurisdiction		Time Period		PHF	1.00
Urban Street	Archer Rd	Analysis Year	2020	Analysis Period	3> 12:30
Intersection	Archer Rd & 13th St	File Name	7360_Archer Rd @ 13th St_Off Peak.xus		
Project Description					



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (v), veh/h	476	128	28	32	116	12	64	472	28	28	824	52

Signal Information			
Cycle, s	101.3	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	5.0	33.0	9.1	28.0	0.0	0.0
Yellow	4.0	4.4	3.7	4.3	0.0	0.0
Red	2.0	2.4	3.1	2.2	0.0	0.0



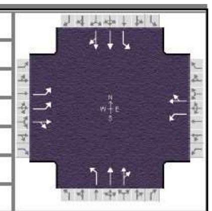
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		8		4	1	6		2
Case Number		10.0		10.0	2.0	4.0		6.3
Phase Duration, s		34.5		15.9	11.0	50.8		39.8
Change Period, (Y+R c), s		6.5		6.8	6.0	6.8		6.8
Max Allow Headway (MAH), s		3.2		3.1	3.2	3.1		3.1
Queue Clearance Time (g s), s		13.8		9.0	5.6	11.1		23.6
Green Extension Time (g e), s		1.5		0.3	0.1	3.1		3.0
Phase Call Probability		1.00		0.99	0.83	1.00		1.00
Max Out Probability		0.00		0.00	0.00	0.00		0.00

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	3	8	18	7	4	14	1	6	16	5	2	12
Adjusted Flow Rate (v), veh/h	476	156		32	128		64	253	247	28	445	431
Adjusted Saturation Flow Rate (s), veh/h/ln	1716	1777		1767	1825		1767	1856	1804	857	1856	1795
Queue Service Time (g s), s	11.8	7.1		1.7	7.0		3.6	9.0	9.1	2.3	21.5	21.6
Cycle Queue Clearance Time (g c), s	11.8	7.1		1.7	7.0		3.6	9.0	9.1	2.3	21.5	21.6
Green Ratio (g/C)	0.28	0.28		0.09	0.09		0.05	0.43	0.43	0.33	0.33	0.33
Capacity (c), veh/h	949	491		159	165		88	807	784	350	605	585
Volume-to-Capacity Ratio (X)	0.501	0.317		0.201	0.778		0.731	0.313	0.315	0.080	0.736	0.736
Back of Queue (Q), ft/ln (50 th percentile)	124.1	76.9		19.2	83.5		43.2	97.9	93.7	12	243.7	230.5
Back of Queue (Q), veh/ln (50 th percentile)	4.8	3.0		0.8	3.3		1.7	3.8	3.7	0.5	9.5	9.2
Queue Storage Ratio (RQ) (50 th percentile)	0.12	0.18		0.07	0.32		0.25	0.10	0.10	0.12	0.24	0.24
Uniform Delay (d 1), s/veh	30.8	29.1		42.7	45.1		47.5	18.7	18.8	23.8	30.3	30.3
Incremental Delay (d 2), s/veh	0.2	0.1		0.2	3.0		4.3	0.1	0.1	0.0	0.7	0.7
Initial Queue Delay (d 3), s/veh	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (d), s/veh	30.9	29.2		42.9	48.1		51.8	18.8	18.8	23.8	30.9	31.0
Level of Service (LOS)	C	C		D	D		D	B	B	C	C	C
Approach Delay, s/veh / LOS	30.5	C		47.1	D		22.6	C		30.7	C	
Intersection Delay, s/veh / LOS	29.8						C					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.32	B	2.29	B	1.91	B	2.11	B
Bicycle LOS Score / LOS	1.53	B	0.75	A	0.95	A	1.23	A

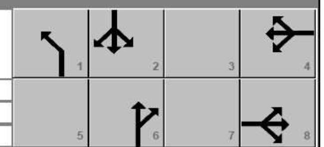
Figure A-24. Summary results for the intersection at Archer Rd and 13th St [Off-peak]

General Information				Intersection Information	
Agency				Duration, h	0.25
Analyst		Analysis Date	7/13/2020	Area Type	Other
Jurisdiction		Time Period		PHF	1.00
Urban Street	Archer Rd	Analysis Year	2020	Analysis Period	1> 16:30
Intersection	Archer Rd & 13th St	File Name	7360_Archer Rd @ 13th St_Evening Peak.xus		
Project Description					



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (v), veh/h	600	268	52	40	92	12	52	584	32	28	1140	80

Signal Information										
Cycle, s	114.4	Reference Phase	2							
Offset, s	0	Reference Point	End	Green	4.9	42.6	8.6	32.2	0.0	0.0
Uncoordinated	Yes	Simult. Gap E/W	On	Yellow	4.0	4.4	3.7	4.3	0.0	0.0
Force Mode	Fixed	Simult. Gap N/S	On	Red	2.0	2.4	3.1	2.2	0.0	0.0



Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		8		4	1	6		2
Case Number		10.0		10.0	2.0	4.0		6.3
Phase Duration, s		38.7		15.4	10.9	60.3		49.4
Change Period, ($Y+R_c$), s		6.5		6.8	6.0	6.8		6.8
Max Allow Headway (MAH), s		3.2		3.1	3.2	3.1		3.1
Queue Clearance Time (g_s), s		20.0		8.4	5.3	14.3		38.1
Green Extension Time (g_e), s		2.3		0.2	0.0	4.6		4.4
Phase Call Probability		1.00		0.99	0.81	1.00		1.00
Max Out Probability		0.00		0.00	0.00	0.00		0.06

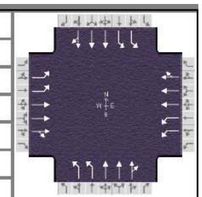
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	3	8	18	7	4	14	1	6	16	5	2	12
Adjusted Flow Rate (v), veh/h	600	320		40	104		52	311	305	28	620	600
Adjusted Saturation Flow Rate (s), veh/h/ln	1716	1784		1767	1818		1767	1856	1809	783	1856	1792
Queue Service Time (g_s), s	17.4	18.0		2.5	6.4		3.3	12.3	12.3	2.7	36.0	36.1
Cycle Queue Clearance Time (g_c), s	17.4	18.0		2.5	6.4		3.3	12.3	12.3	4.0	36.0	36.1
Green Ratio (g/C)	0.28	0.28		0.08	0.08		0.04	0.47	0.47	0.37	0.37	0.37
Capacity (c), veh/h	966	502		133	137		75	868	846	346	692	669
Volume-to-Capacity Ratio (X)	0.621	0.637		0.301	0.761		0.692	0.359	0.360	0.081	0.896	0.898
Back of Queue (Q), ft/ln (50 th percentile)	186.9	201.4		28.3	78.2		40.1	135.2	129.2	13.1	439	417.1
Back of Queue (Q), veh/ln (50 th percentile)	7.3	7.9		1.1	3.1		1.6	5.3	5.2	0.5	17.1	16.7
Queue Storage Ratio (RQ) (50 th percentile)	0.19	0.47		0.11	0.30		0.24	0.14	0.13	0.13	0.44	0.43
Uniform Delay (d_1), s/veh	35.8	36.0		50.1	51.9		54.1	19.5	19.5	24.2	33.8	33.8
Incremental Delay (d_2), s/veh	0.2	0.5		0.5	3.3		4.2	0.1	0.1	0.0	6.5	6.9
Initial Queue Delay (d_3), s/veh	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (d), s/veh	36.1	36.5		50.6	55.2		58.3	19.6	19.6	24.2	40.3	40.7
Level of Service (LOS)	D	D		D	E		E	B	B	C	D	D
Approach Delay, s/veh / LOS	36.2	D		53.9	D		22.6	C		40.2	D	
Intersection Delay, s/veh / LOS	35.7						D					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.32	B	2.29	B	1.91	B	2.11	B
Bicycle LOS Score / LOS	2.01	B	0.73	A	1.04	A	1.52	B

Figure A-25. Summary results for the intersection at Archer Rd and 13th St [PM peak]

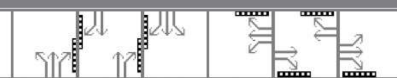
A.2.7 – Archer Rd at 34th St

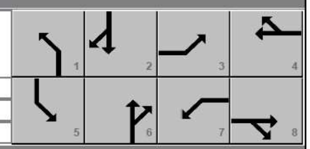
General Information				Intersection Information	
Agency				Duration, h	0.25
Analyst		Analysis Date	7/13/2020	Area Type	Other
Jurisdiction		Time Period		PHF	1.00
Urban Street	Archer Rd	Analysis Year	2020	Analysis Period	1> 7:30
Intersection	Archer Rd @ 34th	File Name	7350_Archer Rd @ 34th St_Morning Peak.xus		
Project Description					



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (v), veh/h	272	1568	104	104	580	164	112	624	140	312	400	128

Signal Information										
Cycle, s	177.9	Reference Phase	2							
Offset, s	0	Reference Point	End	Green	8.8	29.0	23.8	7.6	38.7	25.7
Uncoordinated	Yes	Simult. Gap E/W	On	Yellow	4.9	4.9	4.9	5.0	5.0	5.0
Force Mode	Fixed	Simult. Gap N/S	On	Red	2.3	2.3	2.3	2.6	2.6	2.6





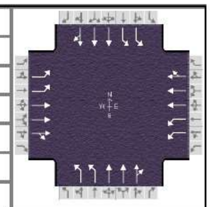
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	3	8	7	4	1	6	5	2
Case Number	2.0	4.0	2.0	4.0	2.0	4.0	2.0	4.0
Phase Duration, s	33.3	79.6	15.2	61.4	16.0	52.2	31.0	67.2
Change Period, (Y+R c), s	7.6	7.6	7.6	7.6	7.2	7.2	7.2	7.2
Max Allow Headway (MAH), s	4.4	4.4	4.0	4.6	7.0	4.5	4.4	4.4
Queue Clearance Time (g s), s	15.1	48.6	7.3	23.4	7.7	25.4	17.4	16.2
Green Extension Time (g e), s	10.6	13.4	0.3	4.2	1.1	3.8	4.1	4.3
Phase Call Probability	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00
Max Out Probability	0.41	0.12	0.00	0.00	0.00	0.03	0.00	0.00

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	3	8	18	7	4	14	1	6	16	5	2	12
Adjusted Flow Rate (v), veh/h	272	1133	539	104	522	222	112	534	230	312	367	161
Adjusted Saturation Flow Rate (s), veh/h/ln	1716	1856	1762	1716	1856	1510	1716	1856	1539	1716	1856	1503
Queue Service Time (g s), s	13.1	46.6	46.6	5.3	20.3	21.4	5.7	22.3	23.4	15.4	12.9	14.2
Cycle Queue Clearance Time (g c), s	13.1	46.6	46.6	5.3	20.3	21.4	5.7	22.3	23.4	15.4	12.9	14.2
Green Ratio (g/C)	0.14	0.40	0.40	0.04	0.30	0.30	0.05	0.25	0.25	0.13	0.34	0.34
Capacity (c), veh/h	496	1501	713	146	1123	457	169	939	389	459	1252	507
Volume-to-Capacity Ratio (X)	0.549	0.755	0.756	0.712	0.465	0.486	0.662	0.569	0.592	0.680	0.293	0.318
Back of Queue (Q), ft/ln (50 th percentile)	148.1	548	517.3	63.3	241.5	204.3	73.3	274.4	243.2	175.3	154.8	137.4
Back of Queue (Q), veh/ln (50 th percentile)	5.8	21.4	20.7	2.5	9.4	8.2	2.9	10.7	9.7	6.8	6.0	5.5
Queue Storage Ratio (RQ) (50 th percentile)	0.36	0.55	0.53	0.18	0.24	0.21	0.17	0.27	0.25	0.72	0.15	0.14
Uniform Delay (d 1), s/veh	70.7	45.4	45.4	84.1	50.3	50.7	83.1	58.0	58.4	73.4	43.4	43.8
Incremental Delay (d 2), s/veh	0.9	1.5	3.2	6.3	0.4	1.0	14.9	2.5	6.5	1.8	0.6	1.6
Initial Queue Delay (d 3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (d), s/veh	71.7	46.9	48.6	90.4	50.7	51.7	98.0	60.5	64.9	75.2	44.0	45.4
Level of Service (LOS)	E	D	D	F	D	D	F	E	E	E	D	D
Approach Delay, s/veh / LOS	50.8	D		55.8	E		66.4	E		55.8	E	
Intersection Delay, s/veh / LOS	55.7						E					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.76	C	2.76	C	2.76	C	2.76	C
Bicycle LOS Score / LOS	1.56	B	0.95	A	0.97	A	0.95	A

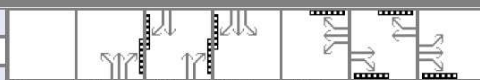
Figure A-26. Summary results for the intersection at Archer Rd and 34th St [AM peak]

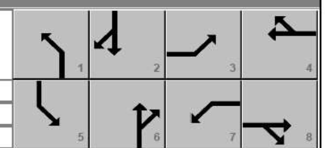
General Information				Intersection Information		
Agency				Duration, h	0.25	
Analyst		Analysis Date	7/13/2020	Area Type	Other	
Jurisdiction		Time Period		PHF	1.00	
Urban Street	Archer Rd	Analysis Year	2020	Analysis Period	1> 12:00	
Intersection	Archer Rd @ 34th	File Name	7350_Archer Rd @ 34th St_Off Peak.xus			
Project Description						



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (v), veh/h	244	864	60	184	1092	308	256	476	100	256	624	180

Signal Information										
Cycle, s	186.9	Reference Phase	2							
Offset, s	0	Reference Point	End	Green	18.1	19.7	33.1	12.4	38.7	20.4
Uncoordinated	Yes	Simult. Gap E/W	On	Yellow	4.9	4.9	4.9	5.0	5.0	5.0
Force Mode	Fixed	Simult. Gap N/S	On	Red	2.3	2.3	2.3	2.6	2.6	2.6





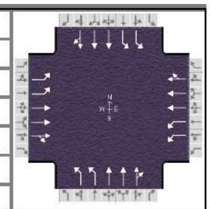
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	3	8	7	4	1	6	5	2
Case Number	2.0	4.0	2.0	4.0	2.0	4.0	2.0	4.0
Phase Duration, s	28.0	74.4	20.0	66.3	25.3	52.2	40.3	67.2
Change Period, (Y+R c), s	7.6	7.6	7.6	7.6	7.2	7.2	7.2	7.2
Max Allow Headway (MAH), s	4.4	4.4	4.0	4.6	7.0	4.5	4.4	4.4
Queue Clearance Time (g s), s	14.7	26.6	11.9	49.0	15.6	20.3	14.4	25.8
Green Extension Time (g e), s	5.7	6.6	0.5	9.7	2.5	2.9	5.7	5.8
Phase Call Probability	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Max Out Probability	0.09	0.00	0.00	0.03	0.03	0.00	0.01	0.01

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	3	8	18	7	4	14	1	6	16	5	2	12
Adjusted Flow Rate (v), veh/h	244	626	298	184	996	404	256	399	177	256	565	239
Adjusted Saturation Flow Rate (s), veh/h/ln	1716	1856	1754	1716	1856	1506	1716	1856	1551	1716	1856	1512
Queue Service Time (g s), s	12.7	24.4	24.6	9.9	47.0	47.0	13.6	17.1	18.3	12.4	22.8	23.8
Cycle Queue Clearance Time (g c), s	12.7	24.4	24.6	9.9	47.0	47.0	13.6	17.1	18.3	12.4	22.8	23.8
Green Ratio (g/C)	0.11	0.36	0.36	0.07	0.31	0.31	0.10	0.24	0.24	0.18	0.32	0.32
Capacity (c), veh/h	375	1326	627	228	1166	473	333	893	373	608	1191	485
Volume-to-Capacity Ratio (X)	0.650	0.472	0.476	0.808	0.854	0.854	0.769	0.446	0.475	0.421	0.474	0.493
Back of Queue (Q), ft/ln (50 th percentile)	145.9	288.6	270.3	117.1	570.3	465.3	168.3	210.1	190.5	139.6	276.1	236.9
Back of Queue (Q), veh/ln (50 th percentile)	5.7	11.3	10.8	4.6	22.3	18.6	6.6	8.2	7.6	5.5	10.8	9.5
Queue Storage Ratio (RQ) (50 th percentile)	0.36	0.29	0.28	0.33	0.57	0.48	0.40	0.21	0.20	0.57	0.28	0.24
Uniform Delay (d 1), s/veh	79.8	46.4	46.5	86.1	60.1	60.1	82.4	60.4	60.8	68.4	50.8	51.2
Incremental Delay (d 2), s/veh	1.9	0.3	0.7	6.6	3.0	7.0	12.6	1.6	4.3	0.5	1.4	3.5
Initial Queue Delay (d 3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (d), s/veh	81.7	46.8	47.2	92.7	63.0	67.0	95.0	62.0	65.1	68.8	52.2	54.7
Level of Service (LOS)	F	D	D	F	E	E	F	E	E	E	D	D
Approach Delay, s/veh / LOS	54.2	D		67.5	E		72.8	E		56.8	E	
Intersection Delay, s/veh / LOS	62.7						E					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.76	C	2.76	C	2.76	C	2.76	C
Bicycle LOS Score / LOS	1.13	A	1.36	A	0.95	A	1.07	A

Figure A-27. Summary results for the intersection at Archer Rd and 34th St [Off-peak]

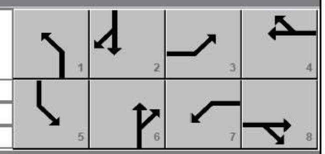
General Information				Intersection Information	
Agency				Duration, h	0.25
Analyst		Analysis Date	7/13/2020	Area Type	Other
Jurisdiction		Time Period		PHF	1.00
Urban Street	Archer Rd	Analysis Year	2020	Analysis Period	2> 16:45
Intersection	Archer Rd @ 34th	File Name	7350_Archer Rd @ 34th St_Evening Peak.xus		
Project Description					



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (v), veh/h	188	804	56	180	1836	520	168	512	112	252	720	220

Signal Information			
Cycle, s	207.3	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	13.6	24.2	28.6	13.2	69.2	14.1
Yellow	4.9	4.9	4.9	5.0	5.0	5.0
Red	2.3	2.3	2.3	2.6	2.6	2.6



Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	3	8	7	4	1	6	5	2
Case Number	2.0	4.0	2.0	4.0	2.0	4.0	2.0	4.0
Phase Duration, s	21.7	98.5	20.8	97.6	20.8	52.2	35.8	67.2
Change Period, ($Y+R_c$), s	7.6	7.6	7.6	7.6	7.2	7.2	7.2	7.2
Max Allow Headway (*MAH*), s	4.4	4.4	4.0	4.5	7.0	4.5	4.5	4.5
Queue Clearance Time (g_s), s	13.2	23.9	12.7	92.0	12.0	25.1	16.2	35.3
Green Extension Time (g_e), s	0.9	5.8	0.5	0.0	1.7	3.0	6.7	6.4
Phase Call Probability	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Max Out Probability	0.05	0.00	0.00	1.00	0.00	0.01	0.03	0.06

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	3	8	18	7	4	14	1	6	16	5	2	12
Adjusted Flow Rate (v), veh/h	188	582	278	180	1628	728	168	435	189	252	667	273
Adjusted Saturation Flow Rate (s), veh/h/ln	1716	1856	1761	1716	1856	1558	1716	1856	1523	1716	1856	1478
Queue Service Time (g_s), s	11.2	21.6	21.9	10.7	90.0	90.0	10.0	21.5	23.1	14.2	32.3	33.3
Cycle Queue Clearance Time (g_c), s	11.2	21.6	21.9	10.7	90.0	90.0	10.0	21.5	23.1	14.2	32.3	33.3
Green Ratio (g/C)	0.07	0.44	0.44	0.06	0.43	0.43	0.07	0.22	0.22	0.14	0.29	0.29
Capacity (c), veh/h	234	1627	772	219	1611	760	226	805	331	474	1074	428
Volume-to-Capacity Ratio (X)	0.804	0.358	0.361	0.822	1.011	0.957	0.745	0.540	0.573	0.532	0.621	0.638
Back of Queue (Q), ft/ln (50 th percentile)	132.8	254.9	239.6	128.3	1444.9	1234.8	126.5	269	240.8	161.9	399.4	333.5
Back of Queue (Q), veh/ln (50 th percentile)	5.2	10.0	9.6	5.0	56.4	49.4	4.9	10.5	9.6	6.3	15.6	13.3
Queue Storage Ratio (RQ) (50 th percentile)	0.32	0.26	0.25	0.36	1.45	1.27	0.30	0.27	0.25	0.66	0.40	0.34
Uniform Delay (d_1), s/veh	95.3	38.8	38.8	95.9	58.7	58.7	95.2	72.0	72.6	83.1	63.8	64.2
Incremental Delay (d_2), s/veh	6.4	0.2	0.3	7.5	25.1	23.6	16.1	2.6	7.1	0.9	2.7	7.1
Initial Queue Delay (d_3), s/veh	0.0	0.0	0.0	0.0	42.4	25.5	0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (d), s/veh	101.6	38.9	39.2	103.4	126.3	107.8	111.2	74.6	79.6	84.1	66.5	71.3
Level of Service (LOS)	F	D	D	F	F	F	F	E	E	F	E	E
Approach Delay, s/veh / LOS	50.3		D	119.3		F	83.6		F	71.3		E
Intersection Delay, s/veh / LOS	91.0						F					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	2.76	C	2.76	C	2.76	C	2.76	C
Bicycle LOS Score / LOS	1.06	A	1.88	B	0.92	A	1.14	A

Figure A-28. Summary results for the intersection at Archer Rd and 34th St [PM peak]

Appendix B – Average Travel Times and Speeds for Study Corridors

B.1 – Average Travel Time along the Study Corridors

Table B-1. Average weekdays and weekend travel times (s) along W Univ. Ave (Sections 1 and 2)

Section 1				
Time of Day	Average Travel Times (s)			
	Eastbound		Westbound	
	Weekdays	Weekend	Weekdays	Weekend
AM peak	211	145	151	150
Off-peak	172	148	154	159
PM peak	215	150	178	156
Section 2				
Time of Day	Average Travel Times (s)			
	Eastbound		Westbound	
	Weekdays	Weekend	Weekdays	Weekend
AM peak	92	97	83	77
Off-peak	101	104	107	92
PM peak	119	104	116	95

Table B-2. Average weekdays and weekend travel times (s) along 13th St and Archer Rd (Section 3)

Time of Day	Average Travel Times (s)			
	Northeast bound		Southwest bound	
	Weekdays	Weekend	Weekdays	Weekend
AM peak	368	287	265	226
Off-peak	364	294	307	253
PM peak	483	310	338	280

Table B-3. Average weekdays and weekend travel times (s) along Archer Rd (Section 4)

Time of Day	Average Travel Times (s)			
	Eastbound		Westbound	
	Weekdays	Weekend	Weekdays	Weekend
AM peak	229	107	158	117
Off-peak	145	111	165	137
PM peak	189	111	365	156

Table B-4. Average weekdays and weekend travel times (s) along 34th St (Sections 5 and 6)

Section 5				
Time of Day	**Average Travel Times (s)**			
	Northbound		**Southbound**	
	Weekdays	Weekend	Weekdays	Weekend
AM peak	64	56	74	62
Off-peak	69	64	83	87
PM peak	67	67	140	88
Section 6				
Time of Day	**Average Travel Times (s)**			
	Northbound		**Southbound**	
	Weekdays	Weekend	Weekdays	Weekend
AM peak	178	129	128	117
Off-peak	160	159	129	132
PM peak	216	171	213	135

B.2 – Speed along the Study Corridors

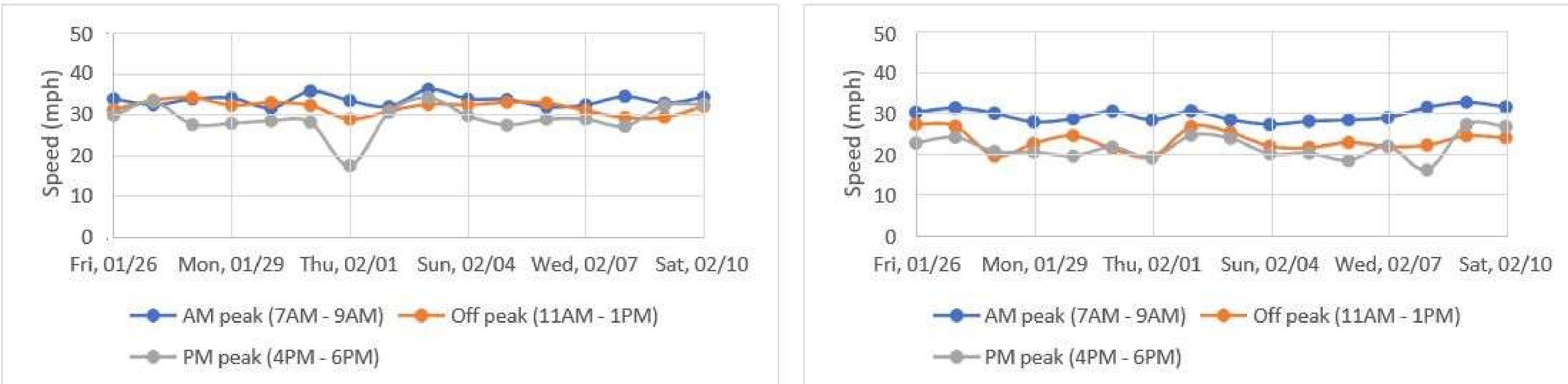


Figure B-1. Speed along W Univ. Ave (WB): Section 1 (left); Section 2 (right)

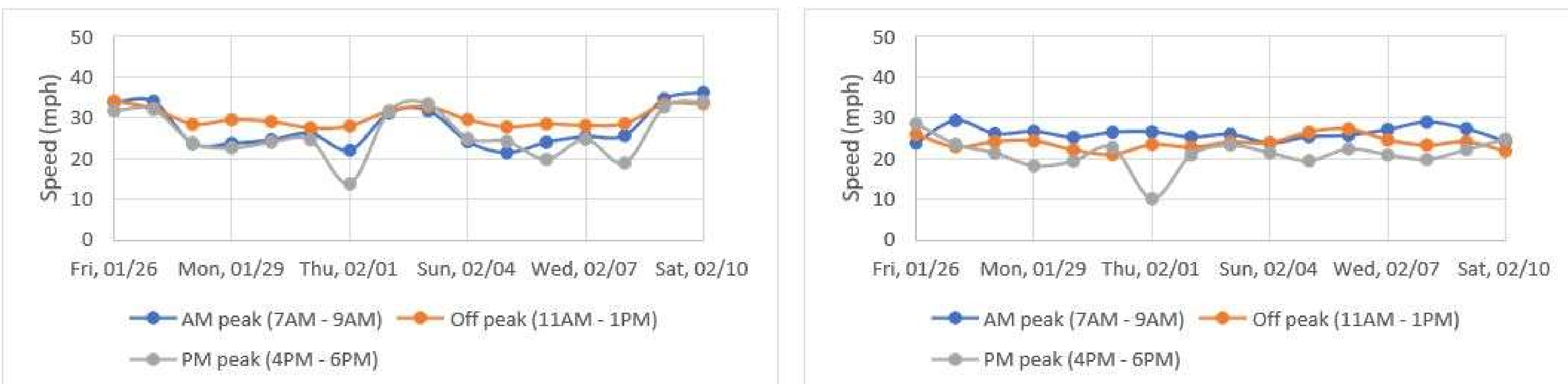


Figure B-2. Speed along W Univ. Ave (EB): Section 1 (left); Section 2 (right)

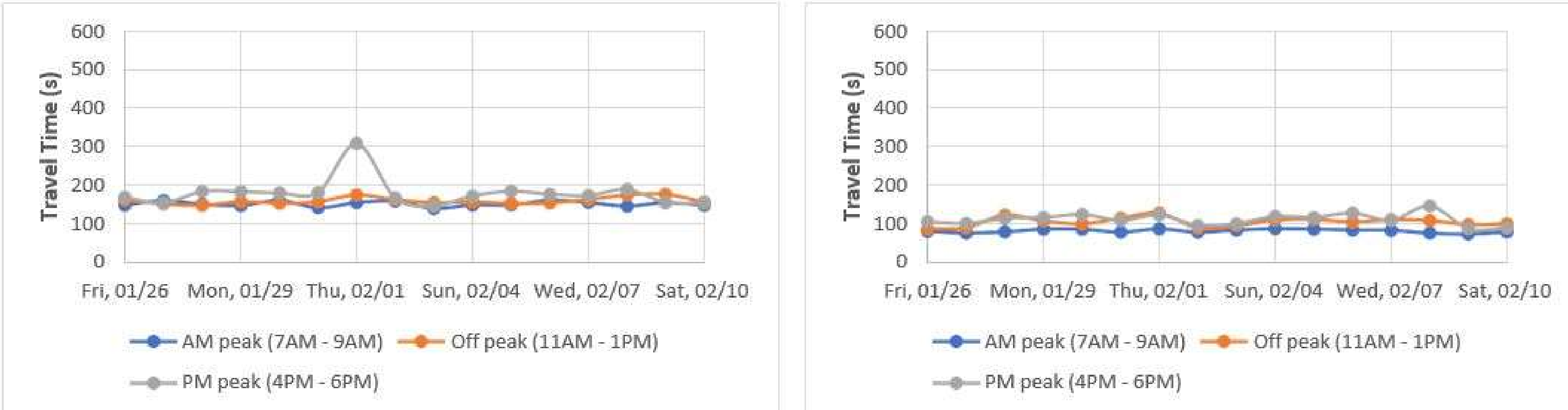


Figure B-3. Travel time along W Univ. Ave (WB): Section 1 (left); Section 2 (right)

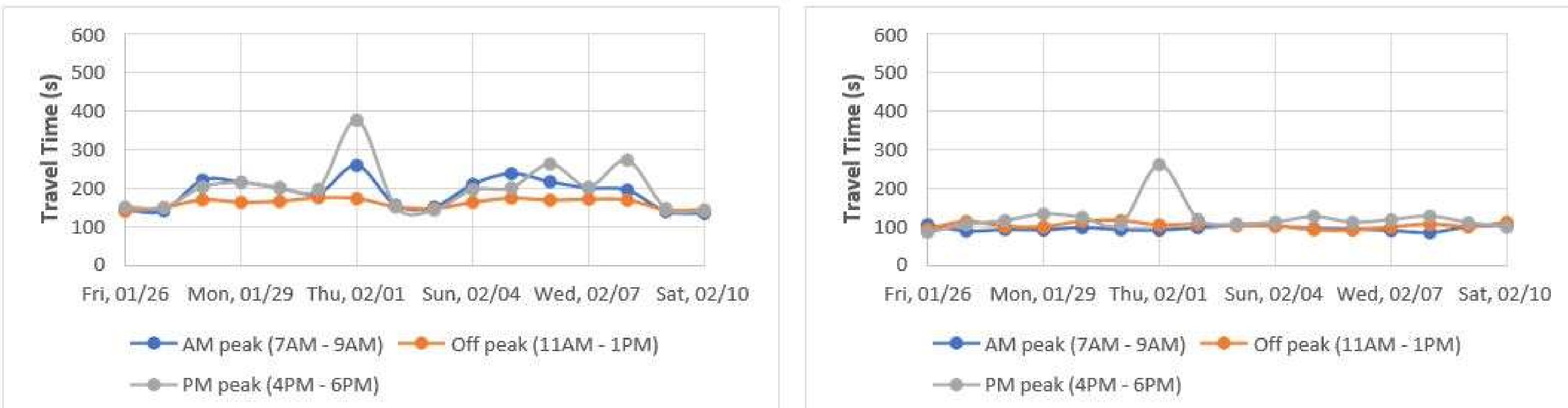


Figure B-4. Travel time along W Univ. Ave (EB): Section 1 (left); Section 2 (right)

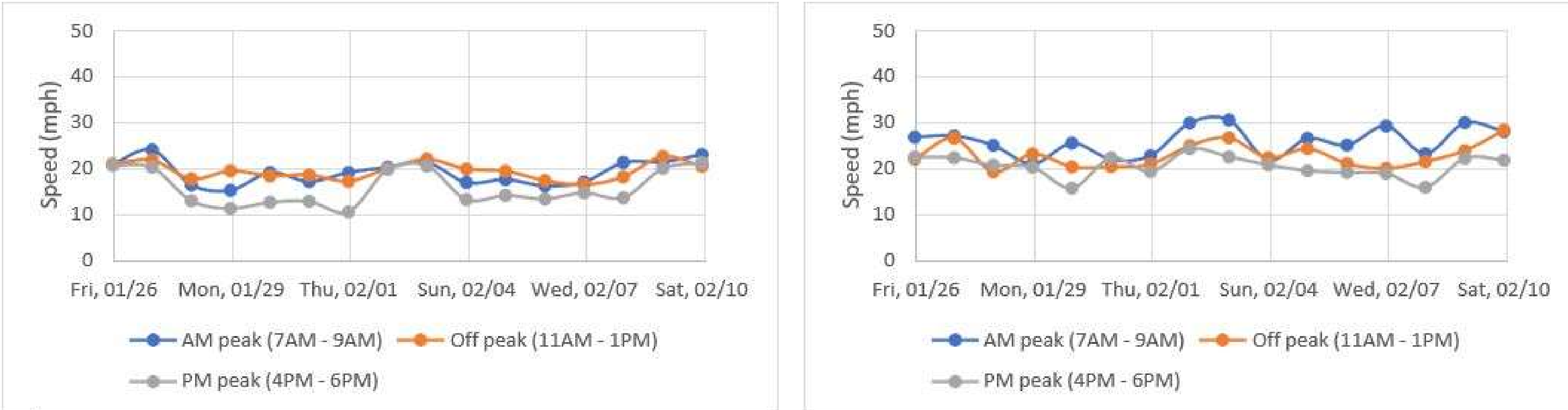


Figure B-5. Speed along 13th St (Section 3): NE – Archer Rd at 16th Ave to W Univ. Ave at 13th St (left); SW – W Univ. Ave at 13th St to Archer Rd at 16th Ave (right)

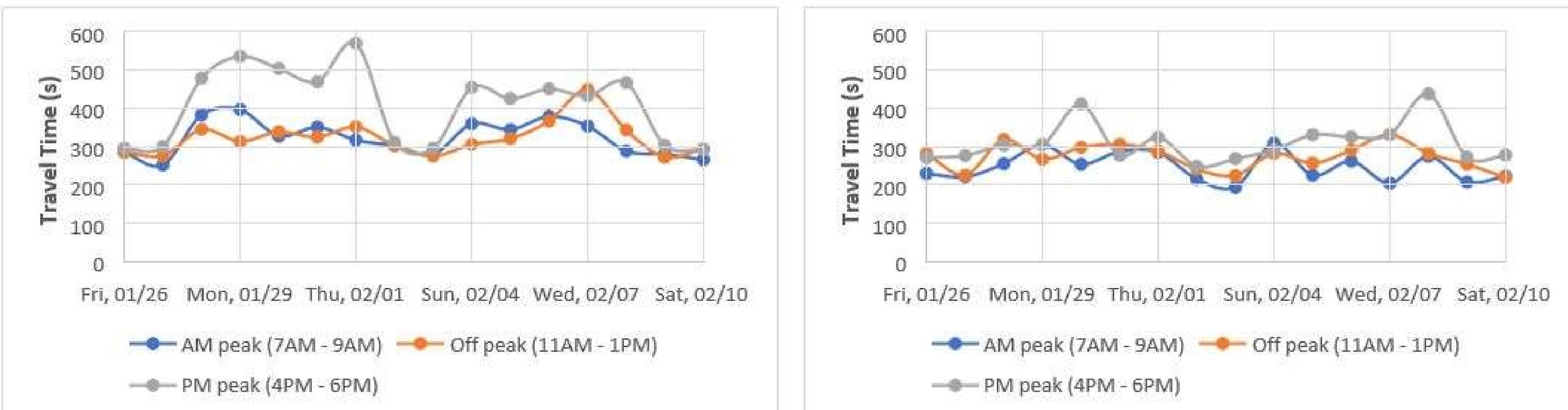


Figure B-6. Travel time along 13th St (Section 3): NE – Archer Rd at 16th Ave to W Univ. Ave at 13th St (left); SW – W Univ. Ave at 13th St to Archer Rd at 16th Ave (right)

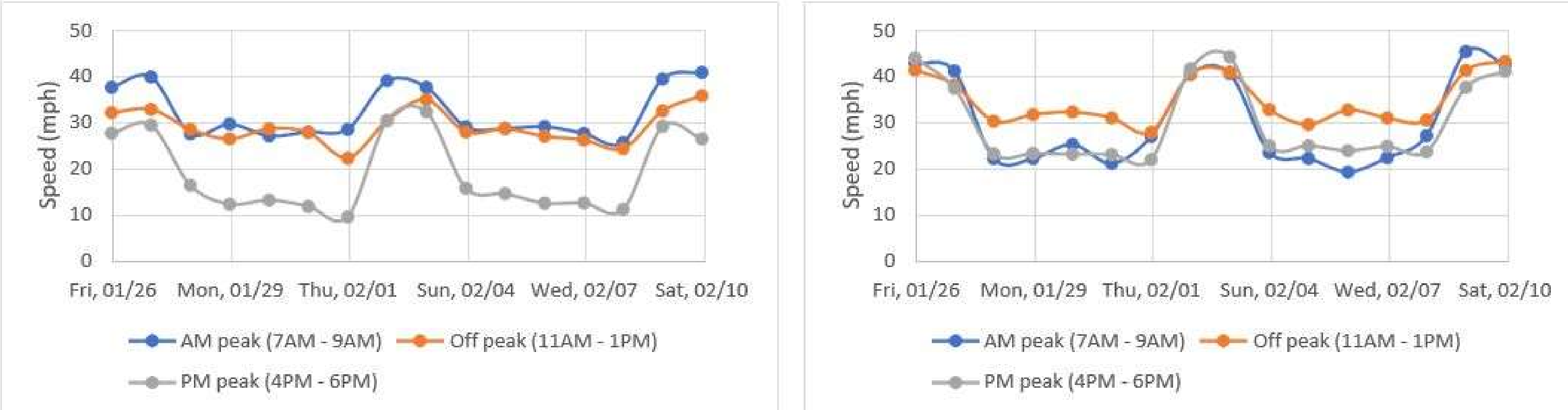


Figure B-7. Speed along Archer Rd (Section 4): WB – 16th Ave to 34th St (left); EB – 34th St to 16th Ave (right)

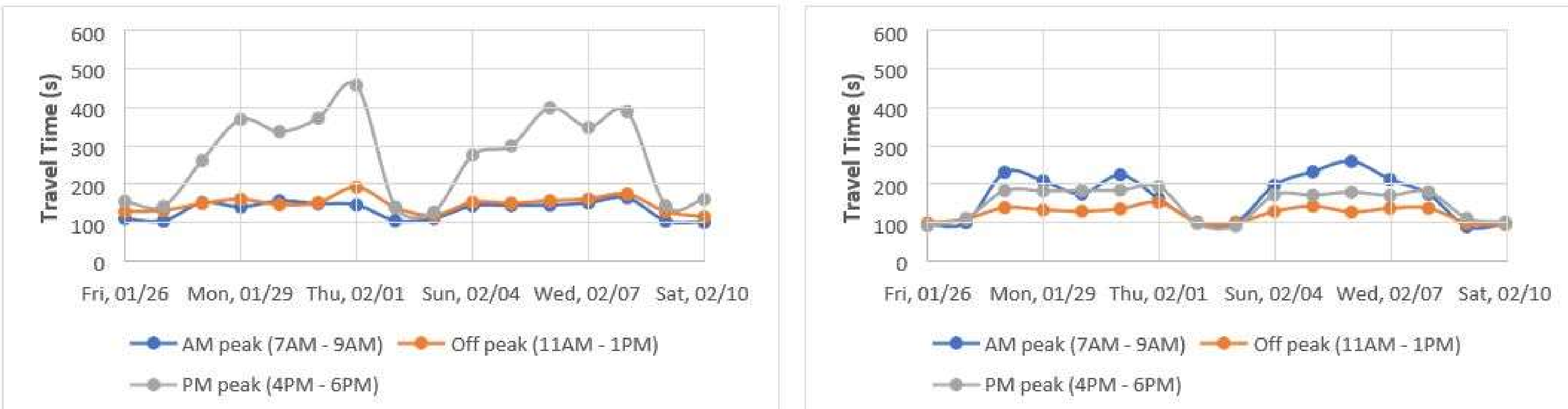
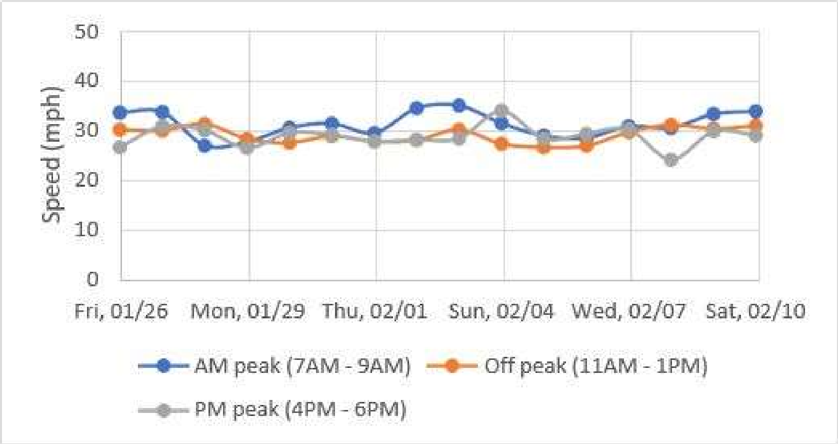


Figure B-8. Travel time along Archer Rd (Section 4): WB – 16th Ave to 34th St (left); EB – 34th St to 16th Ave (right)



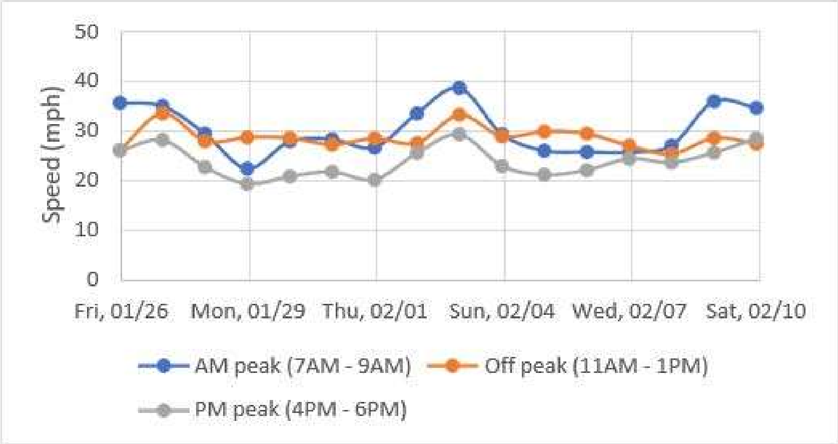
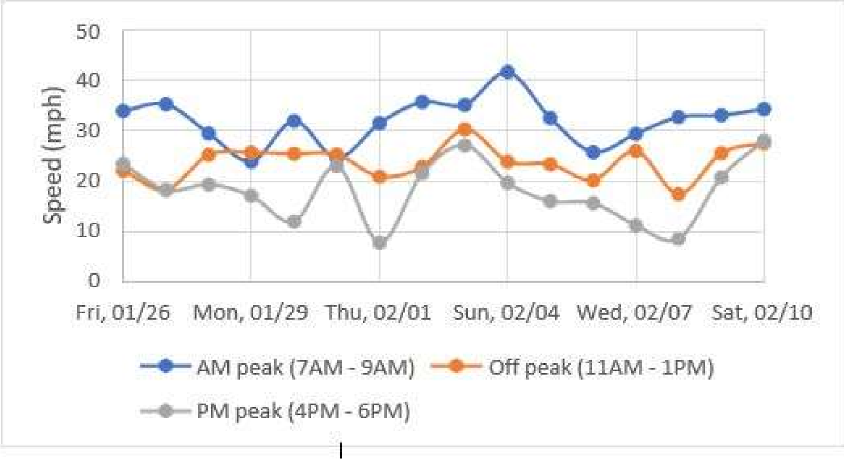


Figure B-9. Speed along 34th St (NB): Section 5 (left); Section 6 (right)



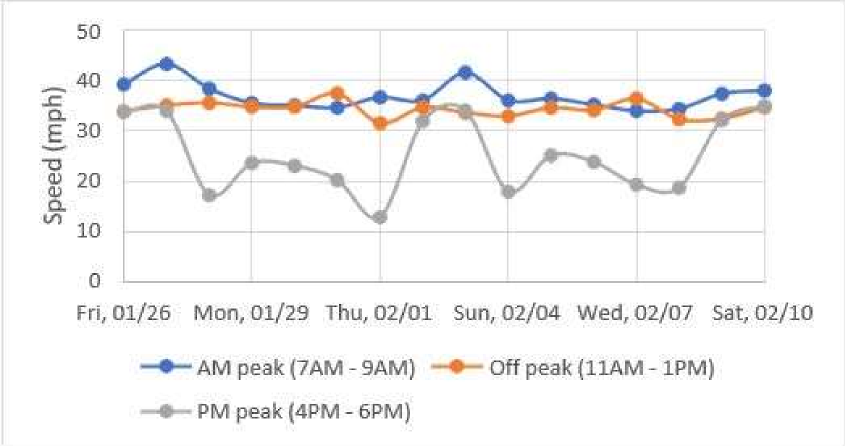
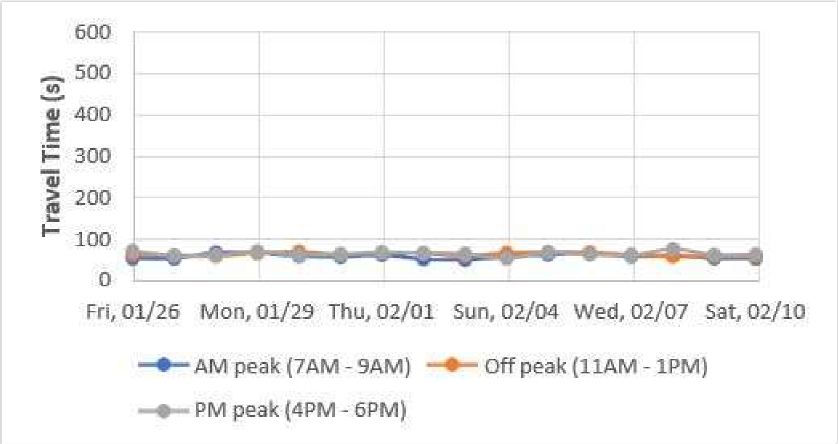


Figure B-10. Speed along 34th St (SB): Section 5 (left); Section 6 (right)



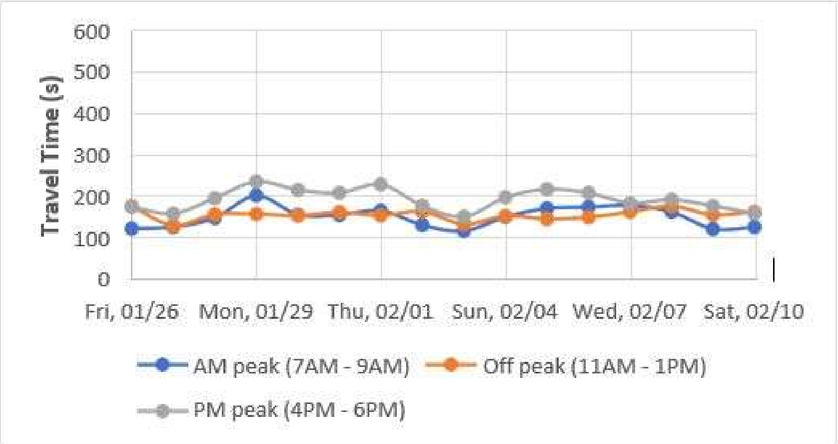
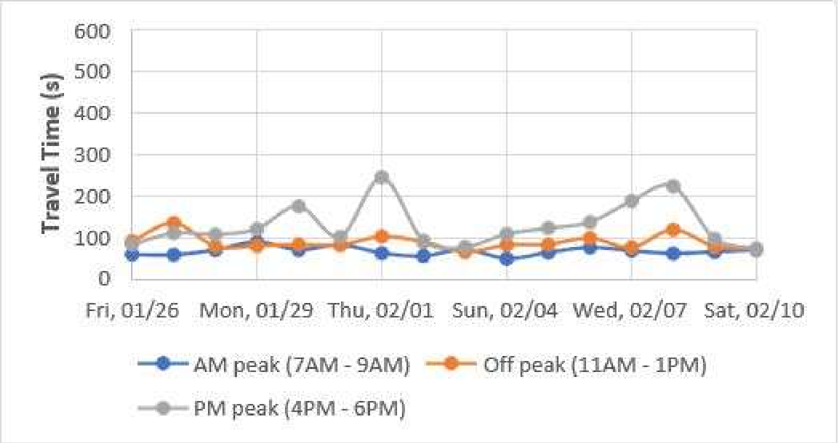


Figure B-11. Travel time along 34th St (NB): Section 5 (left); Section 6 (right)



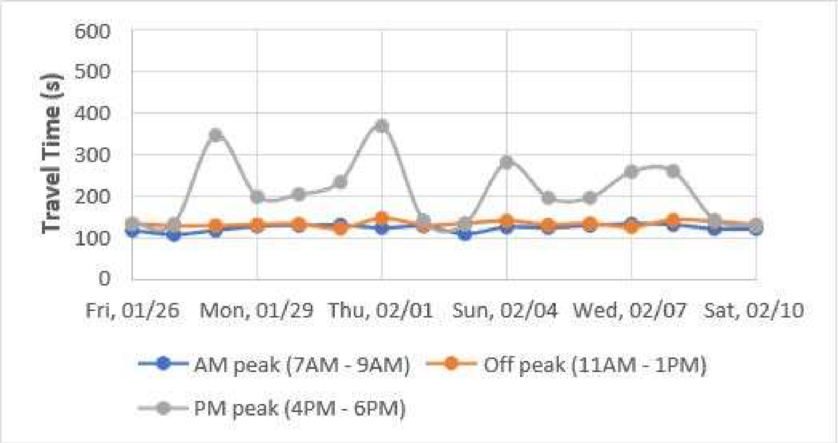


Figure B-12. Travel time along 34th St (SB): Section 5 (left); Section 6 (right)

B.3 – Travel Time Data, Graphs, and Speed Data

Table B-5. Travel times for Section 1

Month	Direction	Day	Travel Time (s)		
			AM Peak	Off-Peak	PM Peak
Jan–Feb 2020	EB	WD	211	172	215
		WE	145	148	150
	WB	WD	151	154	178
		WE	150	159	156
April 2020	EB	WD	147.1	153.2	154
		FR	144.8	153.2	154.9
		WE	140.4	143.7	143.1
	WB	WD	163.5	160	170.6
		FR	167.7	162.8	167.9
		WE	159.8	169.9	172.4
June 2020	EB	WD	159.5	171	172.1
		FR	151	166.1	167.6
		WE	151	147.2	144.3
	WB	WD	176.4	167.9	169
		FR	161	165.3	171.7
		WE	160.2	163.3	173.7
Oct. 2020	EB	WD	168.4	170.8	187.9
		FR	162.1	170.3	197.2
		WE	149.5	151.4	150.5
	WB	WD	168	168.4	181.8
		FR	169.9	164.5	220.6
		WE	164.5	171.3	172.6
Feb. 2021	EB	WD	190	183.5	206.9
		FR	183.7	179	202.6
		WE	195.7	164.1	158.8
	WB	WD	193.6	181.2	194
		FR	180	181.2	209.7
		WE	199	172.1	185.2

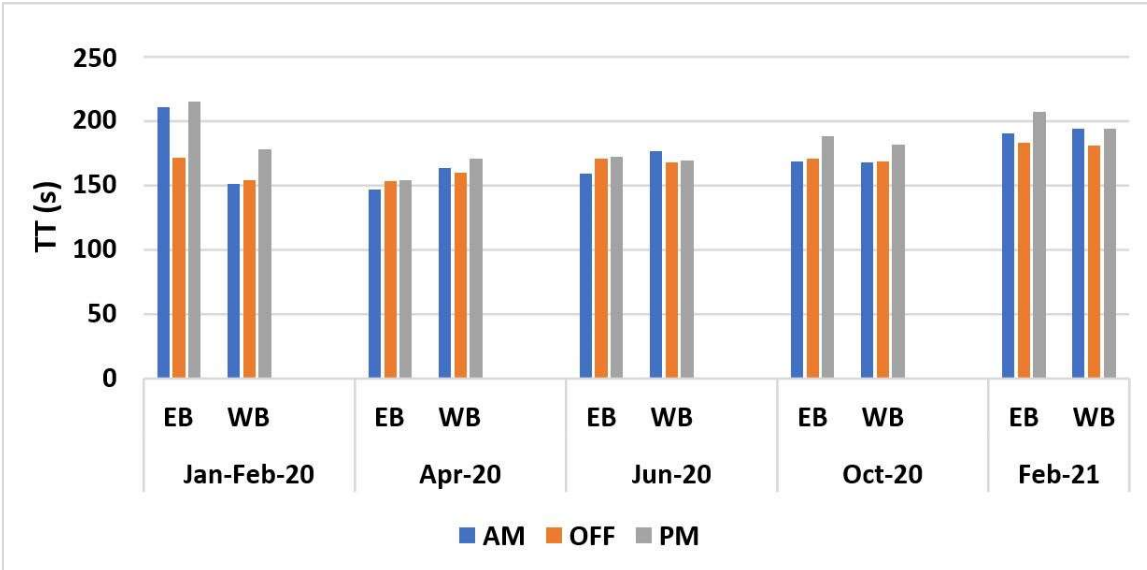


Figure B-13. Comparison of weekday travel times on Section 1 before and after

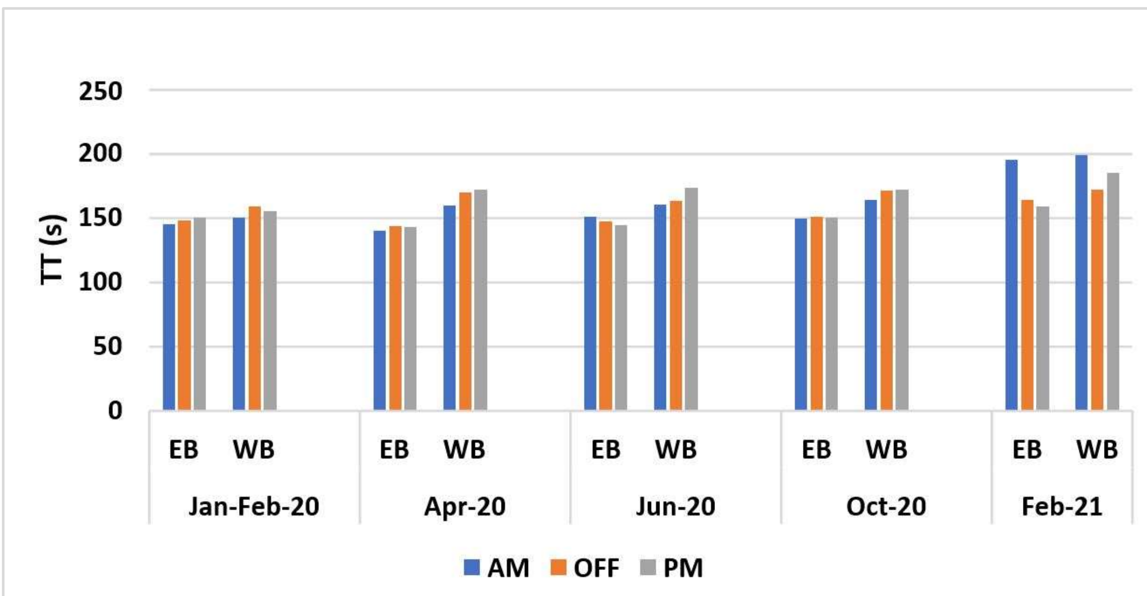


Figure B-14. Comparison of weekend travel times on Section 1 before and after

Table B-6. Travel times for Section 2

Month	Direction	Day	Travel Time (s)		
			AM Peak	Off-Peak	PM Peak
Jan–Feb 2020	EB	WD	92	101	119
		WE	97	104	104
	WB	WD	83	107	116
		WE	77	92	95
April 2020	EB	WD	93.4	90.2	100.5
		FR	85.8	88.6	95.3
		WE	84.5	85.3	84.4
	WB	WD	68.3	74.2	76.6
		FR	70	74.7	73
		WE	66.5	70.2	70.5
June 2020	EB	WD	89.5	90.5	97.3
		FR	96.1	93.7	97.8
		WE	87.3	88.9	86.6
	WB	WD	71.4	82.7	80.1
		FR	70.4	83.7	80
		WE	72.8	77.1	75.9
Oct. 2020	EB	WD	99.3	102	107.5
		FR	99.6	97.9	107.8
		WE	100.2	96	105.2
	WB	WD	85.8	126.9	153.5
		FR	79.8	122	132.5
		WE	75.4	104.4	103
Feb. 2021	EB	WD	117.3	103.9	119
		FR	125.5	100.7	117.4
		WE	186.5	112.9	112.3
	WB	WD	105.4	132.6	162.6
		FR	114.2	155.6	172.9
		WE	162.2	121.7	132.5

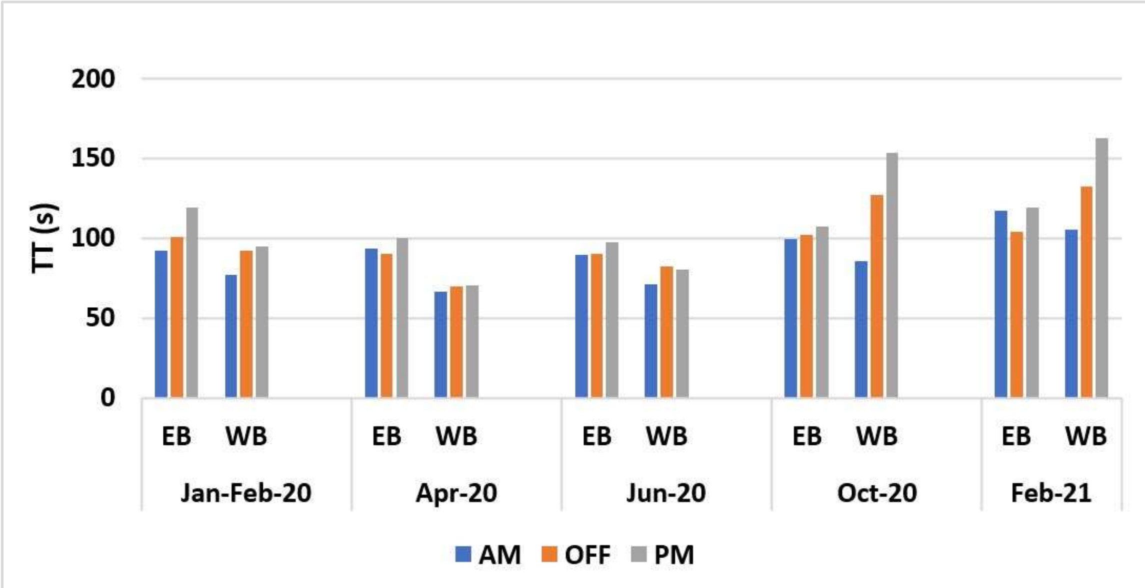


Figure B-15. Comparison of weekday travel times on Section 2 before and after

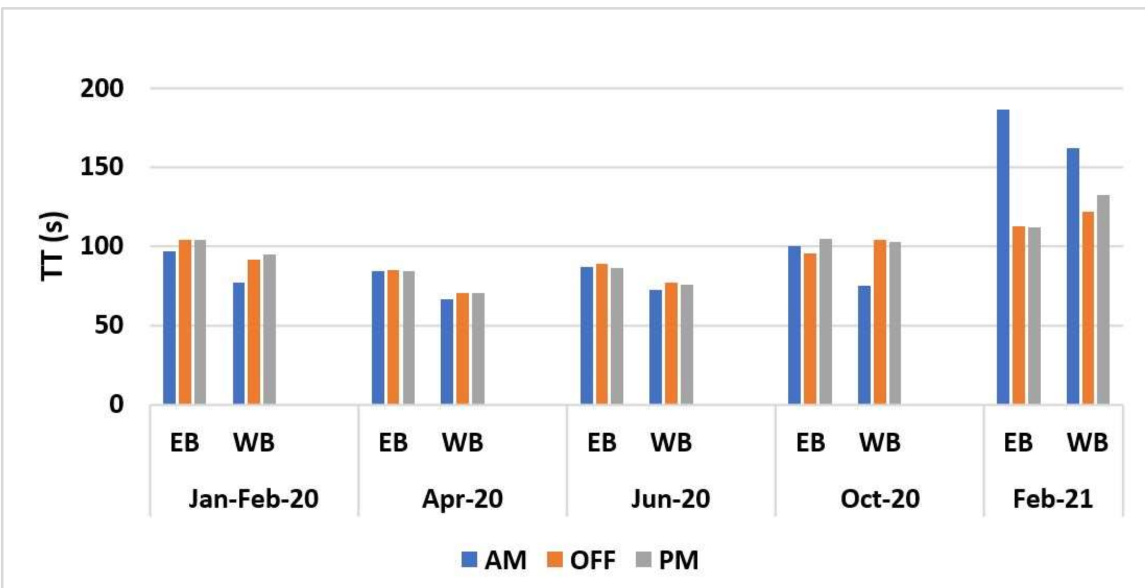


Figure B-16. Comparison of weekday travel times on Section 2 before and after

Table B-7. Travel times for Section 3

Month	Direction	Day	Travel Time (s)		
			AM Peak	Off-Peak	PM Peak
Jan–Feb 2020	NEB	WD	368	364	483
		WE	287	294	310
	SWB	WD	265	307	253
		WE	226	253	280
April 2020	NEB	WD	341.5	304.4	321.4
		FR	336.2	300.2	313.8
		WE	274	274.6	283.3
	SWB	WD	223.1	229.1	244.6
		FR	243.3	232	229.3
		WE	222	209.5	211.9
June 2020	NEB	WD	312.2	283.9	314.3
		FR	313.3	265.6	310.6
		WE	247.8	260.3	241.6
	SWB	WD	212.6	242.2	261.9
		FR	228.3	243.1	232.5
		WE	205.4	208.4	224.7
Oct 2020	NEB	WD	322.3	302.5	332.9
		FR	302.3	325.5	358.2
		WE	298.1	296.4	319.4
	SWB	WD	227.1	257.4	290.7
		FR	232.5	256.9	271.9
		WE	242.6	237.5	265.2
Feb 2021	NEB	WD	178	172.7	190.3
		FR	185.3	178.4	197.9
		WE	160.3	161.5	158.3
	SWB	WD	90.1	118.6	106.3
		FR	83.7	124.9	116.6
		WE	100.7	107.5	127.9

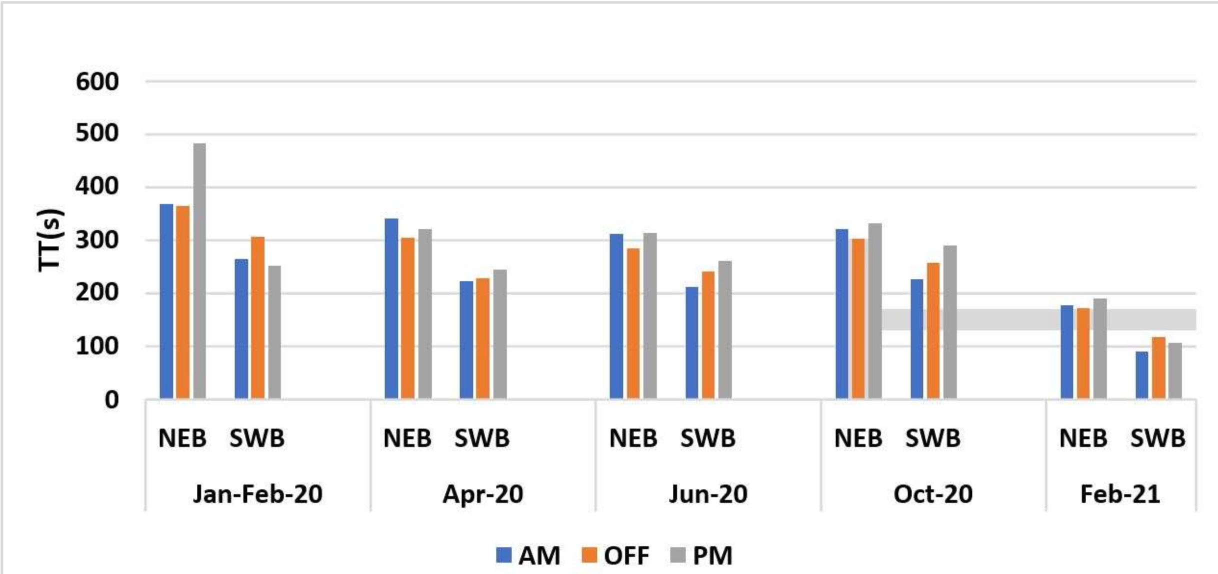


Figure B-17. Comparison of weekday travel times on Section 3 before and after

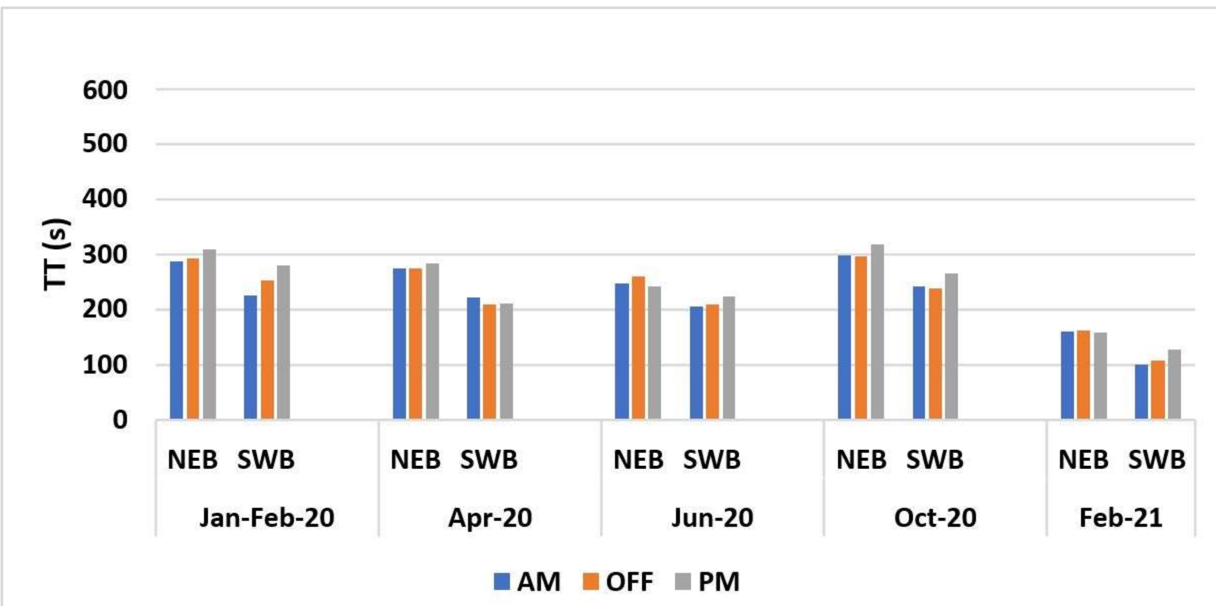


Figure B-18. Comparison of weekday travel times on Section 3 before and after

Table B-8. Travel times for Section 4

Month	Direction	Day	Travel Time (s)		
			AM Peak	Off-Peak	PM Peak
Jan–Feb 2020	EB	WD	229	145	189
		WE	107	111	111
	WB	WD	158	165	365
		WE	117	137	156
April 2020	EB	WD	118.6	132.1	165.1
		FR	118.8	130.9	163.7
		WE	107.9	108.2	108.7
	WB	WD	142.7	125.6	156.5
		FR	138.2	125.1	152.4
		WE	110.7	116.4	115.5
June 2020	EB	WD	133.7	144.5	186
		FR	132	146	182.1
		WE	116.5	108.7	110
	WB	WD	148.9	157.2	188.9
		FR	149.1	156.1	189.7
		WE	119.5	125.3	125
Oct. 2020	EB	WD	149.6	144.6	188.6
		FR	146.8	147.1	190.3
		WE	112.6	111.9	110.1
	WB	WD	150.8	164.6	255.7
		FR	148.6	178	241.6
		WE	133.6	137.8	140.5
Feb. 2021	EB	WD	160	148.4	188.2
		FR	148.4	158.4	185.9
		WE	118.5	106.7	110.2
	WB	WD	155.2	179.4	246.2
		FR	162.4	189.2	240.6
		WE	135.7	144.2	151.2

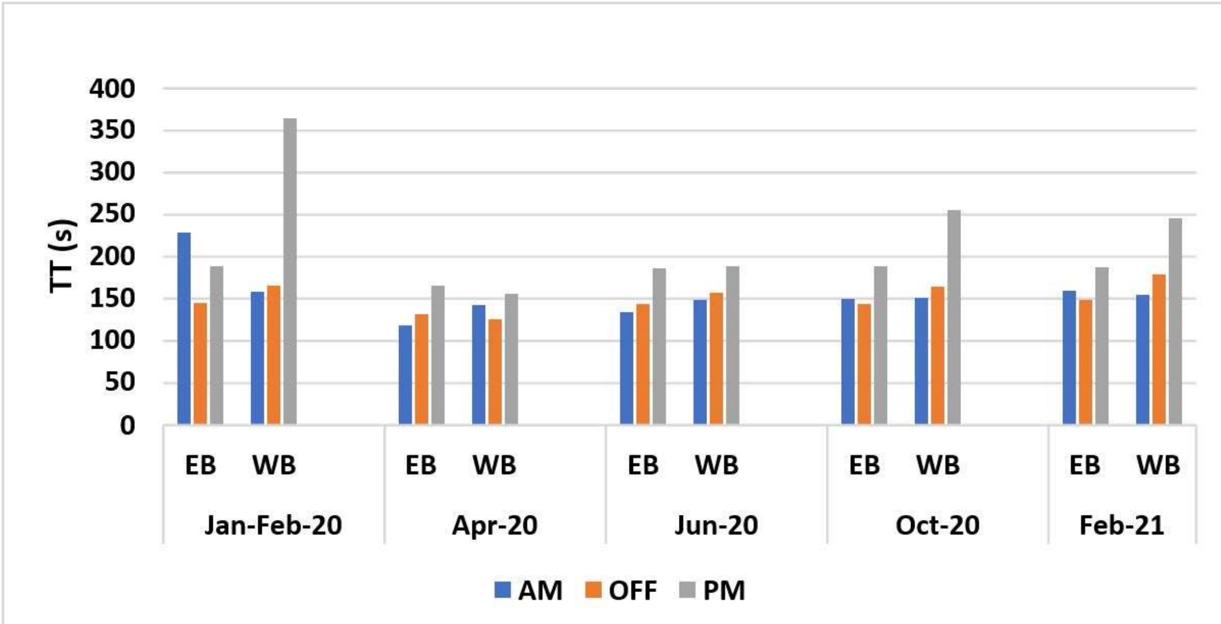


Figure B-19. Comparison of weekday travel times on Section 4 before and after

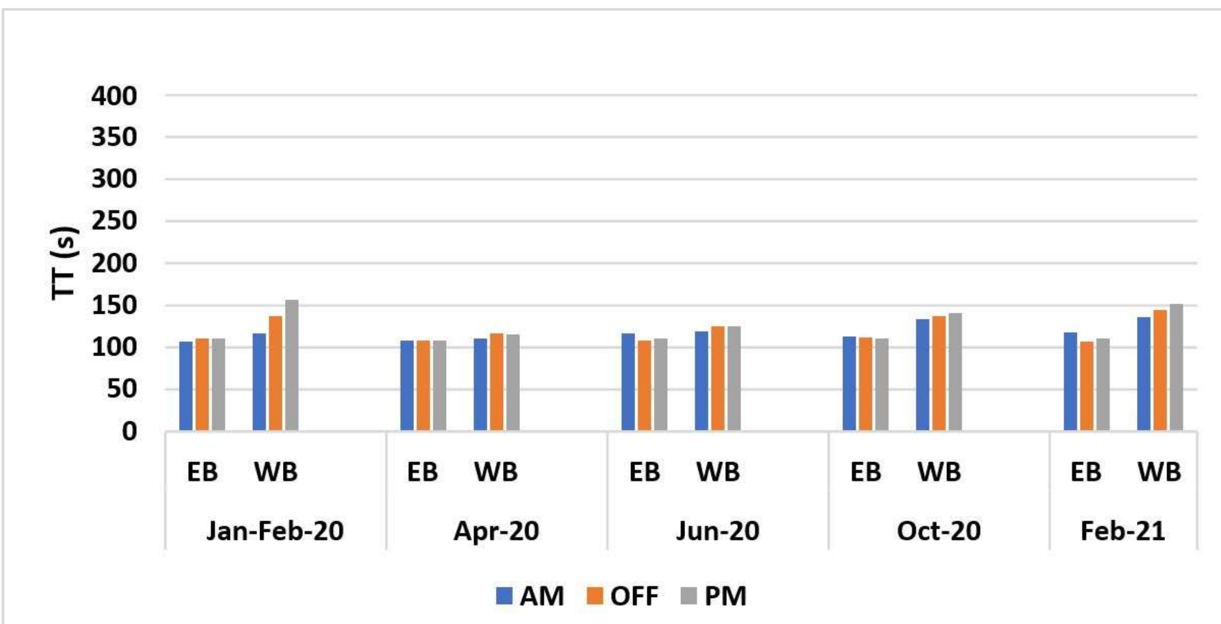


Figure B-20. Comparison of weekday travel times on Section 4 before and after

Table B-9. Travel times for Section 5

Month	Direction	Day	Travel Time (s)		
			AM Peak	Off-Peak	PM Peak
Jan–Feb 2020	NB	WD	64	69	67
		WE	56	64	67
	SB	WD	74	83	140
		WE	62	87	88
April 2020	NB	WD	57	63.1	64.4
		FR	54.9	65.9	61.9
		WE	57.7	59.5	58.6
	SB	WD	62.2	75	77.6
		FR	63.9	83.2	77
		WE	62.4	67.4	73.7
June 2020	NB	WD	55.7	67.1	67.5
		FR	55.4	68	78.5
		WE	54.2	62.4	62.1
	SB	WD	74.6	87.3	89.6
		FR	68.1	87.9	92.3
		WE	62.4	80.7	78.8
Oct. 2020	NB	WD	56.3	68.8	67.2
		FR	53.2	72.4	66
		WE	54.3	59.4	66.6
	SB	WD	76.7	90.2	122.3
		FR	73.1	99.1	134.1
		WE	62.6	79	79.9
Feb. 2021	NB	WD	56	70.6	68.6
		FR	56.4	74.8	68
		WE	59.4	65.1	71.4
	SB	WD	76	97.3	128.9
		FR	81.6	118.7	152.1
		WE	76.6	91	99.1

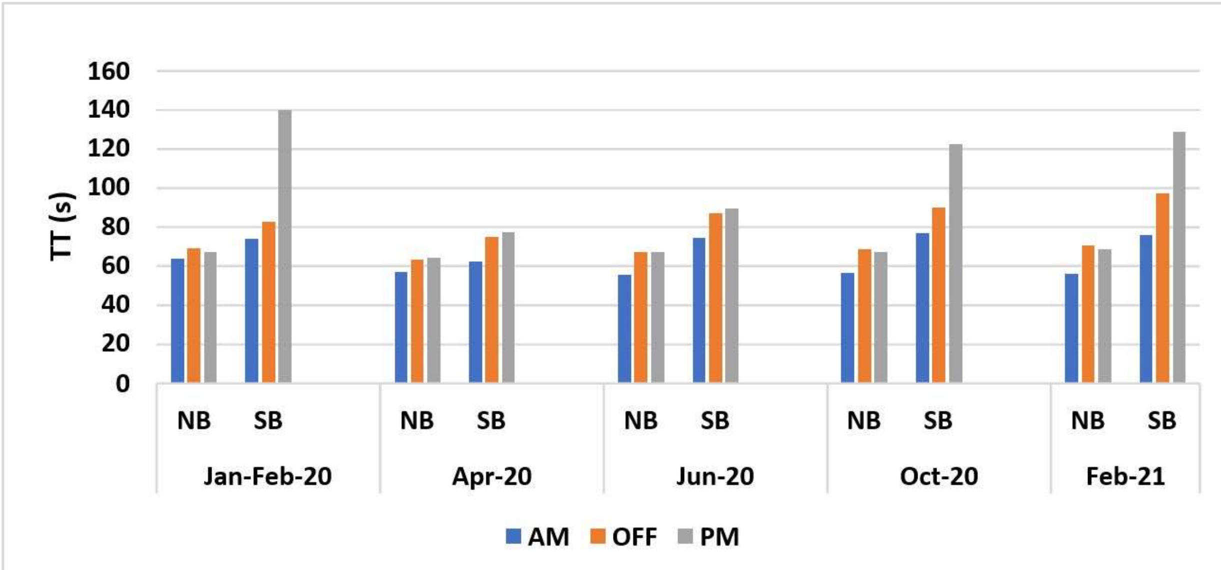


Figure B-21. Comparison of weekday travel times on Section 5 before and after

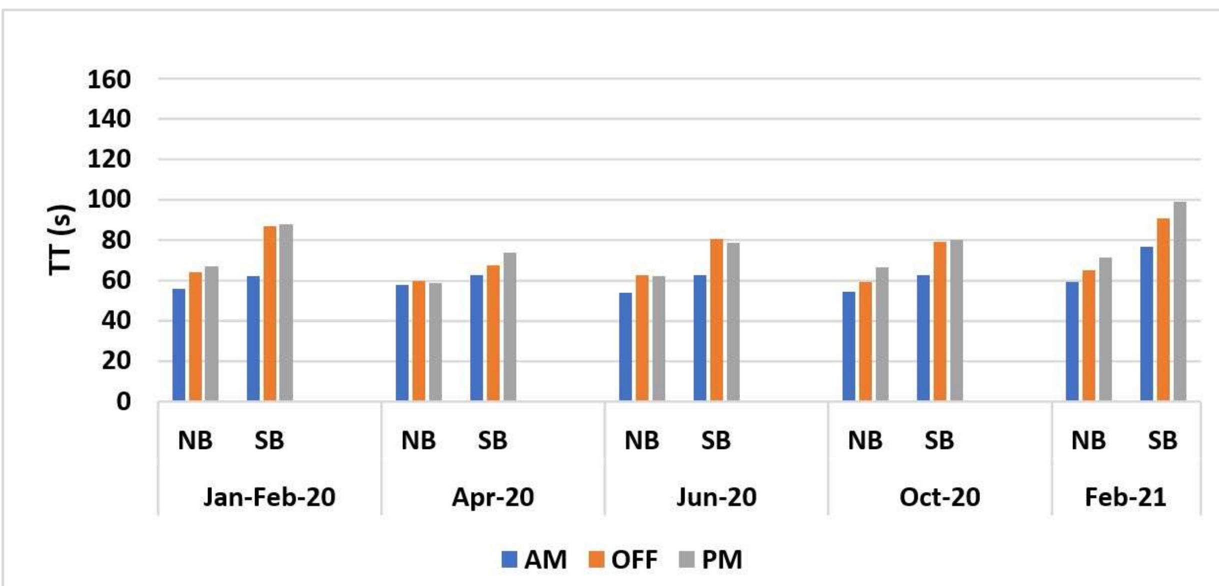


Figure B-22. Comparison of weekday travel times on Section 5 before and after

Table B-10. Travel times for Section 6

Month	Direction	Day	Travel Time (s)		
			AM Peak	Off-Peak	PM Peak
Jan–Feb 2020	NB	WD	178	160	216
		WE	129	159	171
	SB	WD	128	129	213
		WE	117	132	135
April 2020	NB	WD	135.5	144.7	148.9
		FR	125.8	145.1	142.8
		WE	121.4	135	131.1
	SB	WD	110.8	120.4	109
		FR	109.9	120.5	107.6
		WE	113.8	112.8	110.9
June 2020	NB	WD	143.6	161.3	181.1
		FR	142.1	165.1	186.5
		WE	121.1	142.9	144.7
	SB	WD	116.7	132	119.9
		FR	114.6	133.2	117.9
		WE	109.8	116.4	112.4
Oct. 2020	NB	WD	160.4	180.4	222.2
		FR	152.1	187.3	242.9
		WE	132.7	168.8	183.6
	SB	WD	129.1	148.8	145.1
		FR	127.2	150.8	132.4
		WE	118	137.4	127
Feb. 2021	NB	WD	145.4	174	214
		FR	152.6	178	212.2
		WE	133.1	155	161.5
	SB	WD	128.8	154.5	180.9
		FR	128.4	176.6	173.3
		WE	133.6	141.8	141.4

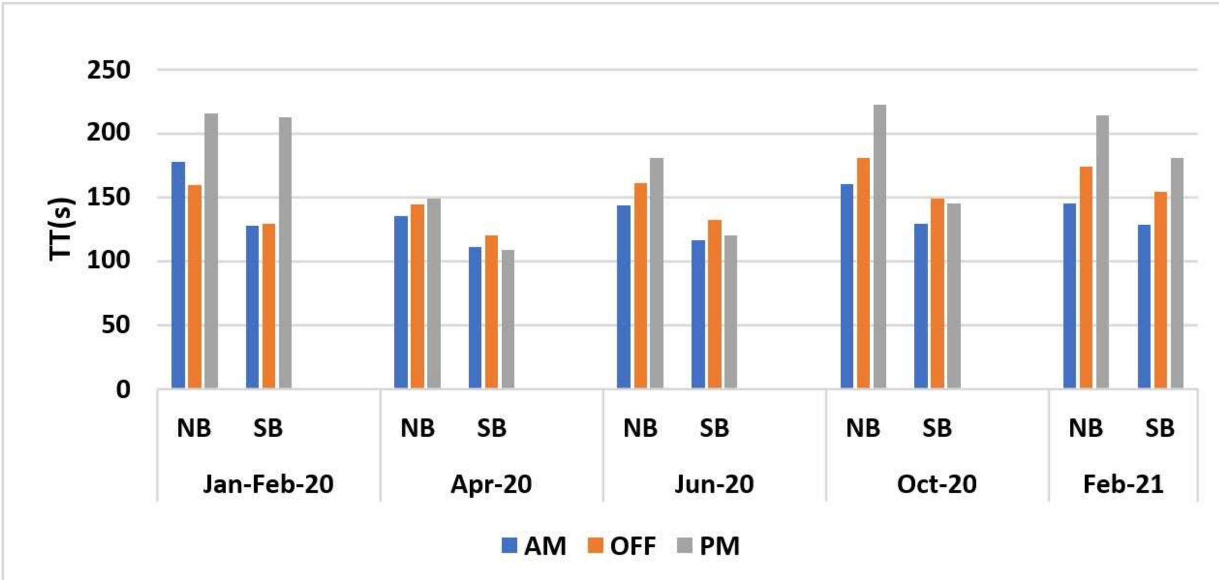


Figure B-23. Comparison of weekday travel times on Section 6 before and after

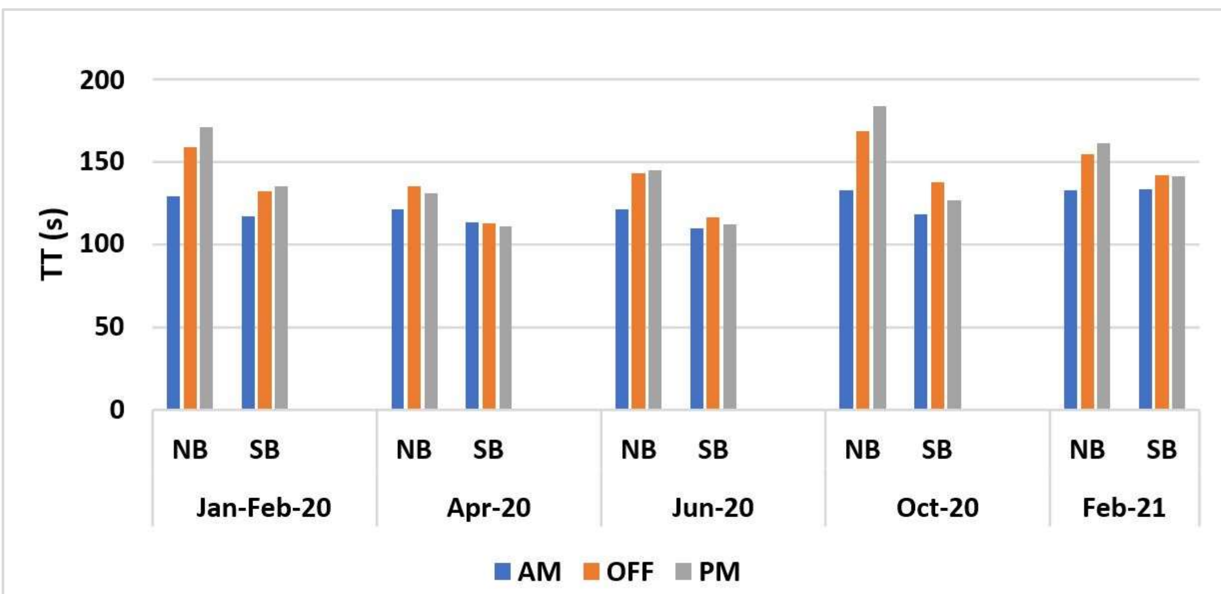


Figure B-24. Comparison of weekday travel times on Section 6 before and after

Table B-11. Average speeds on Section 1

Month	Direction	Day	Speed (mph)		
			AM Peak	Off-Peak	PM Peak
Jan–Feb 2020	EB	WD	24	28	23
		FR	24	28	16
		WE	34	33	33
	WB	WD	33	32	28
		FR	34	29	22
		WE	33	31	32
April 2020	EB	WD	33.1	31.7	31.6
		FR	33.6	31.8	31.4
		WE	34.6	33.8	34
	WB	WD	29.8	30.4	28.6
		FR	29	29.9	29
		WE	30.4	28.7	28.2
June 2020	EB	WD	30.5	28.5	28.3
		FR	32.2	29.3	29.1
		WE	32.2	33.1	33.7
	WB	WD	27.6	29	28.9
		FR	30.3	29.5	28.4
		WE	30.4	29.8	28
Oct. 2020	EB	WD	29	28.5	25.9
		FR	30	28.6	24.8
		WE	32.5	32.2	32.3
	WB	WD	29	28.9	26.8
		FR	28.6	29.6	23.5
		WE	29.6	28.4	28.2
Feb. 2021	EB	WD	25.6	26.5	23.6
		FR	26.5	27.3	24
		WE	25	29.8	30.6
	WB	WD	25.3	26.9	25.2
		FR	27.1	26.8	23.2
		WE	24.5	28.3	26.4

Table B-12. Average speeds on Section 2

Month	Direction	Day	Speed (mph)		
			AM Peak	Off-Peak	PM Peak
Jan–Feb 2020	EB	WD	26	24	20
		FR	28	23	15
		WE	26	23	24
	WB	WD	29	23	21
		FR	30	21	18
		WE	31	26	25
April 2020	EB	WD	25.4	26	23.4
		FR	27.4	26.5	24.7
		WE	27.8	27.5	27.9
	WB	WD	34.3	31.6	30.7
		FR	33.5	31.4	32.1
		WE	35.3	33.3	33.2
June 2020	EB	WD	26.2	26.1	24.1
		FR	24.4	25.1	24
		WE	26.9	26.4	27.2
	WB	WD	32.8	28.5	29.3
		FR	33.3	28.1	29.3
		WE	32.3	30.4	30.9
Oct. 2020	EB	WD	23.6	23.1	21.8
		FR	23.6	24.1	21.7
		WE	23.5	24.5	22.5
	WB	WD	27.5	19.3	16.5
		FR	29.4	19.7	17.9
		WE	31.1	22.6	22.9
Feb. 2021	EB	WD	21.2	22.8	19.8
		FR	19.7	23.5	20.1
		WE	13.3	20.8	21
	WB	WD	23.1	18.2	15
		FR	21.1	15.7	13.8
		WE	15.8	19.4	18.2

Table B-13. Average speeds on Section 3

Month	Direction	Day	Speed (mph)		
			AM Peak	Off-Peak	PM Peak
Jan–Feb2020	NEB	WD	17	18	13
		FR	20	18	12
		WE	22	21	21
	SWB	WD	25	21	19
		FR	23	21	17
		WE	29	25	23
April 2020	NEB	WD	11.4	12.8	12.1
		FR	11.6	13	12.4
		WE	14.2	14.2	13.7
	SWB	WD	11.6	11.3	10.5
		FR	10.8	11.1	11.3
		WE	11.7	12.3	12.2
June 2020	NEB	WD	12.6	13.8	12.4
		FR	12.5	14.7	12.5
		WE	15.7	15	16.1
	SWB	WD	12.2	10.7	9.9
		FR	11.3	10.6	11.1
		WE	12.6	12.4	11.5
Oct. 2020	NEB	WD	12.1	12.9	11.7
		FR	12.9	11.9	10.9
		WE	13.2	13.2	12.2
	SWB	WD	11.4	10	8.9
		FR	11.2	10.1	9.5
		WE	10.6	10.9	9.7
Feb. 2021	NEB	WD	22	22.6	20.6
		FR	21.2	21.9	19.7
		WE	24.6	24.1	24.7
	SWB	WD	29	22	24.4
		FR	30.9	20.8	22.3
		WE	25.7	24.5	20.3

Table B-14. Average speeds on Section 4

Month	Direction	Day	Speed (mph)		
			AM Peak	Off-Peak	PM Peak
Jan–Feb 2020	EB	WD	22	31	24
		FR	27	29	23
		WE	42	41	41
	WB	WD	29	28	13
		FR	27	24	11
		WE	39	33	29
April 2020	EB	WD	37.7	33.9	27.1
		FR	37.6	34.3	27.3
		WE	41.5	41.4	41.1
	WB	WD	31.6	35.8	28.7
		FR	32.7	35.9	29.4
		WE	40.4	38.5	38.7
June 2020	EB	WD	33.5	31	24
		FR	33.9	30.6	24.6
		WE	38.4	41.2	40.8
	WB	WD	30.2	28.6	23.7
		FR	30.2	28.9	23.7
		WE	37.6	35.8	35.8
Oct. 2020	EB	WD	30.4	31	23.7
		FR	31.1	30.5	23.5
		WE	39.7	40	40.6
	WB	WD	29.8	27.2	18.5
		FR	30.4	25.4	19
		WE	33.7	32.5	31.8
Feb. 2021	EB	WD	29.4	30.2	23.8
		FR	30.4	28.2	24
		WE	38.1	42	40.6
	WB	WD	29	25.1	18.5
		FR	27.8	23.8	18.7
		WE	33.1	31.2	29.6

Table B-15. Average speeds on Section 5

Month	Direction	Day	Speed (mph)		
			AM Peak	Off-Peak	PM Peak
Jan–Feb 2020	NB	WD	30	28	29
		FR	30	29	26
		WE	34	30	29
	SB	WD	28	25	16
		FR	32	19	8
		WE	35	25	23
April 2020	NB	WD	32.4	29.3	28.8
		FR	33.5	27.9	29.9
		WE	31.9	30.9	31.4
	SB	WD	30.9	25.3	24.1
		FR	29.9	22.3	24
		WE	29.6	27.8	25.5
June 2020	NB	WD	33	27.8	27.6
		FR	33.4	27.7	23.7
		WE	34	29.6	29.8
	SB	WD	25.7	21.2	20.9
		FR	27.1	21.4	20
		WE	29.8	23.3	23.7
Oct. 2020	NB	WD	33	27	27.7
		FR	34.6	26.1	28.3
		WE	33.9	31	27.9
	SB	WD	24.2	20.6	16
		FR	25.4	18.7	13.8
		WE	29.7	23.4	23.1
Feb. 2021	NB	WD	33.5	26.7	27.3
		FR	33.6	24.6	27.3
		WE	31.1	28.5	26.2
	SB	WD	24.3	19.3	14.5
		FR	22.8	16	12.5
		WE	24.4	20.7	18.9

Table B-16. Average speeds on Section 6

Month	Direction	Day	Speed (mph) AM Peak	Speed (mph) Off-Peak	Speed (mph) PM Peak
Jan–Feb 2020	NB	WD	26	28	22
		FR	27	27	22
		WE	35	29	27
	SB	WD	35	35	22
		FR	36	32	16
		WE	39	34	33
April 2020	NB	WD	33.1	30.9	30.1
		FR	35.6	30.8	31.3
		WE	36.8	33.1	34.1
	SB	WD	40.4	37.4	41
		FR	40.6	37.5	41.5
		WE	39.3	39.7	40.3
June 2020	NB	WD	31.2	27.8	24.8
		FR	31.6	27.1	24.1
		WE	36.9	31.3	31
	SB	WD	38.3	34.2	37.3
		FR	39	33.9	37.9
		WE	40.8	38.5	39.8
Oct 2020	NB	WD	28	24.8	20.2
		FR	29.5	24	18.6
		WE	33.8	27	24.6
	SB	WD	34.6	31.1	31.1
		FR	35.2	30.4	33.8
		WE	38	32.8	35.2
Feb 2021	NB	WD	30.8	26	21.7
		FR	29.4	25.2	21.3
		WE	33.6	29.4	28
	SB	WD	34.8	29.3	25.5
		FR	35	25.3	26.6
		WE	33.6	31.7	31.6

Appendix C – Interview Questions

1. How often have you used the OBUs?
2. Has the OBU been operational, i.e., showing messages when driving through intersections on Trapezium network (34th St, Archer Rd, W Univ. Ave, and 13th St)?
3. What is your understanding of the messages displayed?
4. How useful were the messages to you as a driver?
5. Were the messages distracting?
6. What is your overall feedback on the functionality of OBU?
7. What specific changes would you recommend to improve the OBU functionality?
8. Do you have any other suggestions for improving the Gainesville/UF highway network?