CE443 Transportation Systems Engineering
Fall 2019

COURSE PROJECT

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Project Description

This course project is designing for improved traffic flow and pedestrian safety around Marshall University campus.

The goal is to evaluate the current state of traffic and pedestrian flow on Third Avenue between 16th and 20th Streets and provide design alternatives as potential improvements.

The scope of this project provides answers to the following concerns:

- How to improve pedestrian safety and traffic flow
- What does 16th and 20th Street on Third Avenue exhibit?
- If a pedestrian island was placed along Third Avenue, what would be the increase in delay and how many lanes might this reduce?
- How would the overall delay be affected by removing the existing signal(s)?
- Can delay be modified by signal timing?
- Other changes that would maybe help the problem

This report includes two (2) proposed design alternatives:

Design Alternative 1 includes improvements to roadway features, reconfiguration of travel lanes, the addition of safety devices, adjustments to traffic speeds and signal timings, as well as beautification enhancements which also serve as safety elements.

Design Alternative 2 includes reconfiguration of travel lanes, adjustments to traffic speeds, signal timings and the addition of safety devices to prevent vehicle "weaving" between lanes in specific areas of increased pedestrian traffic.

Design Standards

The designs and calculations included in this report are in compliance with the 2018 "*Geometric Design of Highways and Streets, 7th Edition*" ("Green Book"), by the American Association of State Highway and Transportation Officials (AASHTO) and the 2016 "*Highway Capacity Manual*" (HCM), by the Transportation Research Board.

Design Software

CADD drawings and 3-dimensional models were created using MicroStation V8i.

Traffic modeling was performed using Synchro ver.10, and includes optimized signal timing, calculation of Level of Service (LOS) and delay times for all intersections within the project area.

Bluebeam Revu 2018 was used for post-production editing.

Evaluation of Existing Conditions

Pedestrian and traffic counts were evaluated in the field at the intersections of 20th, 18th, and 16th Streets in 15-minute intervals (see Table 1). Pedestrians walking in undesignated spots were counted in another hour at different spots.

All counts were compiled into Microsoft Excel and the directional design hourly volume (DDHV) was calculated. For DDHV to be calculated the average annual daily traffic (AADT) was calculated using design factors from the HCM. These design factors include monthly factors (M_j), day of week factors (D_k), the proportion of AADT (K), the directional distribution factor (D), and the Hourly expansion factors (HEF_i). M_j and D_k which was found on page 11-42 in Volume 2 of the HCM. K was 0.12 and D was 1 since Third Avenue is a one-way.

Total Daily Volume and Volume in Hour 1 was found using GEOCOUNTS online. GEOCOUNTS was also utilized for traffic volume at 16th and 3rd Avenue. The LOS and intersection delay were calculated using Synchro.

See Appendix B for further data and calculations regarding LOS and delay.

Table 1. Existing LOS and Intersection Delay

Intersection	LOS	Intersection Delay (s)
3rd Avenue / 16th Street	C	25.4
3rd Avenue / 18th Street	B	18.1
3rd Avenue / 20th Street	D	37.3

Design Alternative 1

Design Alternative 1 is considered a best-case scenario which includes numerous improvements to the Third Avenue corridor between 16th Street and 20th Street. The most substantial improvements include reducing the number of travel lanes from 4 to 3, the addition of a raised 10-foot wide pedestrian refuge island along the entire length of the corridor, installation of a full-width speed table for the crosswalk at the front entrance of the Arthur Weisberg Applied Engineering Complex and reconfiguration of the existing parallel street parking on both sides to angular parking. Lane channelization is also introduced as a method of traffic calming.

Other less substantial improvements include the addition of landscaping planter boxes along the exterior edges of the sidewalks on the north and south sides of Third Avenue to discourage pedestrian jaywalking (a very common practice), and adjustments to signal timings. It is also proposed that the existing posted speed limit of 35 mph be reduced to 30 mph in this area.

Reducing the number of travel lanes and decreasing the speed limit suggests increased pedestrian safety. Frequent operation of the existing corridor resembles a miniature freeway arterial in its function, with vehicle speeds often exceeding 15 to 20 mph over the posted speed limit of 35 mph. The primary goal of Design Alternative 1 is to convert the corridor from its existing "freeway" resemblance into a pedestrian-friendly suburban downtown "main street" concept.

As mentioned previously, one feature of this design alternative is to reconfigure the existing parallel parking on both sides of the corridor to angular parking. Preliminary evaluation indicates that the angular configuration would add 110 parking spaces (estimated), an increase in parking capacity of approximately 230 percent.

The conceptual typical section features (2) – 12′ lanes for thru / left turn traffic southbound onto 16th Street (Hal Greer Boulevard), a 10-foot wide pedestrian refuge island, a 10′ thru / right turn lane and angular parking on both sides of the corridor. This will require widening the existing corridor from 62 feet to 74 feet, which extends the roadway pavement to the exterior edges of existing sidewalk.

See Appendix D for the conceptual typical section.

Traffic Analysis

Field data was obtained to ascertain traffic and pedestrian counts during the peak hour. A detailed analysis of the data was then performed to determine proposed modifications to traffic control as a result of improvements to the corridor. Optimization of the signal timings at all three intersections was evaluated, which resulted in a decrease of intersection delay at 18th Street and slight increases at 16th and 20th Streets (see Table 2).

Table 2. LOS and Intersection Delay (Design Alternative 1)

Intersection	LOS	Intersection Delay (sec)
3rd Avenue / 16th Street	C	29.2
3rd Avenue / 18th Street	A	5.8
3rd Avenue / 20th Street	D	39.2

16th Street Intersection (westbound)

Traffic analysis for this intersection was performed based on 2 left-turn/thru (LTT) lanes and a right-turn/thru (RTT). The Level of Service remained the same at LOS C. The intersection delay increased from 25.4 sec to 29.2 sec.

18th Street Intersection (westbound)

Traffic analysis for this intersection was performed based on 2 lanes provided left of the pedestrian refuge islands, which carry traffic to 2 left-turn/thru (LTT) lanes at 16th Street, and a thru lane on the right side of the islands which carries traffic to a right-turn/thru (RTT) lane at 16th Street. The Level of Service at 18th Street increased from LOS B to LOS A. The intersection delay decreased from 18.1 sec to 5.8 sec.

20th Street Intersection (westbound)

Traffic analysis for this intersection was performed based on a left-turn/thru (LTT) lane, 2 dedicated thru lanes and a right-turn/thru (RTT) lane. The Level of Service remained the same at LOS D. The intersection delay slightly increased from 37.3 sec to 39.2 sec.

Detailed traffic analysis calculations for Design Alternative 1 are available in Appendix C1.

Design Alternative 2

For this design, the speed limit was reduced to 30 mph, the original one-way four lane road was reduced down to a three-lane road, and the signal timing was optimized using Synchro. By reducing the number of lanes and reducing the speed limit, pedestrians have an easier and faster time to cross Third Avenue. Optimizing the signal timing resulted in a decrease in intersection delay overall at each intersection (see Table 3).

Table 2. LOS and Intersection Delay (Design Alternative 2)

Intersection	LOS	Intersection Delay (sec)
3rd Avenue / 16th Street	C	29.2
3rd Avenue / 18th Street	B	10.6
3rd Avenue / 20th Street	C	34.1

Traffic Analysis

At 16th Street and 20th Street headed North on Hal Greer, the original straight through is now a combined straight through and a left turning lane. The original left turning lane is kept. Headed South on 16th Street the original two lanes are reduced to one to increase pedestrian safety and open another option for parking in front of Marshall University's campus. By reducing the number of lanes and optimizing signal timing the LOS and intersection delay decrease. The LOS at 16th and 3rd Avenue will decrease from a LOS of C to a LOS of B. While the intersection delay will decrease from 25.4 (s) to 16.0 (s). The images at each intersection and calculation tables are shown in Appendix C2.

By reducing the fourth lane to three lanes and optimizing signal timing at 18th Street and 3rd Avenue, the LOS and intersection delay will decrease. The LOS at 18th and 3rd Avenue will maintain a LOS of B, however the intersection delay will decrease from 18.1 (s) to 10.6 (s). These values are shown in Table 3 below. The images at each intersection and calculation tables are shown in Appendix C2.

At 20th Street headed north, the original straight through lane is now a combined straight through with a left turning lane. Since the original two separate turning lanes turning lane is reduced to a turning and combined turning lane, this will expand room for an extra lane to be created headed south at 20th Street and reduce the number of lanes on 20th Street in front of the John C. Edwards Stadium. By doing so pedestrians will have an easier time crossing to the football stadium parking lot. The LOS at 20th and 3rd Avenue will decrease from a LOS of D to a LOS of C. Thus, the intersection delay will decrease from 37.3 (s) to 34.1 (s). The LOS and intersection delay values are shown in Table 3. The images at each intersection and calculation tables are shown in Appendix C2.

A conceptual typical section of the corridor is shown in Appendix D.

Summary

Departments of Transportation often seek to justify projects by means of conducting Benefit/Cost analysis. While it can sometimes be challenging to quantify certain benefits and costs which could be gained from a project, assumptions can be made to produce either empirical data or relative data to aid in a more specific analysis of a project's validity. According to Economic Evaluation Primer, "By placing dollar values on user costs, the costs of strategies to maintain traffic flow can be evaluated and compared. In some cases, life-cycle cost analysis may reveal it is less costly for agencies and users to do a temporary road closure than to stretch out construction." This simply brings to light the idea that it is often easier to make decisions which seem to be more readily economical in the short term, as opposed to a more costly decision now with the potential for higher benefit in the future.

These benefits/costs can be categorized into two groups: user and non-user. The "user's" include items such as travel time, operation cost, accidents, discomfort, and delays. These are simply consequences that act upon the users of the travel way themselves, while "non-user's" act upon the environment; items like environmental pollution and neighborhood disruption. It is important to note that benefits and costs items of interest are often common among both groups, and it is simply the projects effect on them (increasing or decreasing) which determines if they are beneficial or costly.

The primary user benefits that these designs are intended to achieve are as follows:

- Travel Time Savings – difference in the time users spend traveling before and after design implementation (scalar attribute)
- Safety Improvements – a reduction in risk/severity for both automobile and pedestrian accidents (subjective index)
- Beautification – an increase of an area's visual appeal falling in line with Huntington's beautification initiative (subjective index)
- Vehicle Operating Cost Reductions – fuel consumption, break wear, tire wear, and use-related vehicle depreciation (subjective index)

It is also important to note for the analysis that the method of measurement for these target benefits vary. These techniques can be classified as either a scalar attribute or a subjective index—with the former having calculated numerical data to demonstrate a benefit, while the former is rated against a scale [such as a scale from 1-10]. This method is utilized when a benefit may not be strictly economical—if at all—but instead offers some sort of communal or environmental benefit.

For this project, it is not within the scope of work to create a fully fleshed cost breakdown of the construction of the various alternatives. In place of such a review, a weighted cost analysis has been conducted to compare the alternative designs against one another. This method bears similarity to the subjective index method mentioned above in that it does not convey a precise dollar amount to describe design alternatives. Instead, the two designs are compared exclusively against one another [as well as against the existing

condition]. This allows for an ability to get a sense for potential construction costs without the need for more robust appraising tools.

Analysis

Travel Time Savings—being a scalar attribute—was calculated directly for both design alternatives using output data from their respective Synchro simulations. More specifically, intersection delay time [s] for Designs 1 and 2 were compared against the existing delay for each intersection to obtain a "Delta Intersection Delay" (s). This parameter illustrates the improvement or decline that the design has affected on each intersection. A travel time value of $12/hr was assumed and used in conjunction with Synchro's Traffic Volume [veh/hr] outputs for each intersection to obtain the total benefit that the design offers the area expressed in $/hr. It was shown from the calculations that the "LOST" design offered a greater total benefit concerning delay time. These calculations can be seen in detail in Appendix B; a sampling of the results can be found in the table below.

DESIGN 1 VS EXISTING			
Intersection	**Δ Intersection Delay (s)**	**Benefit/Cost ($/hr)**	**Total Benefit ($/hr)**
16th and 3rd Avenue	-3.8	-$34.69	$50.94
18th and 3rd Avenue	12.3	$106.89	
20th and 3rd Avenue	-1.9	-$21.25	

Concerning the subjective index components of the analysis, a basic 1-10 scale was adopted to rate the improvement of each parameter relative to each other as well as to the existing baseline condition. It can be seen in the table below how the design improved or declined the condition (formatted cells indicate highest rating), and that Design 1 improves upon most parameters while slightly decreases efficient vehicle operating costs. This result falls in line with what is expected, as it allows pedestrians safer passage, implements planers, foliage, and walls, as well as adding additional obstacles for vehicles—such as speed tables—while decreasing the speed limit. These factors clearly correlate to an increase in both safety and beautification, while vehicles would likely experience slightly more resistance. It should be noted that though these values are subjective, their strength lies in their relationship with one another. While the specific 1-10 number may be different from individual to individual, the relative proportions are expected to remain relatively consistent.

As mentioned above, a fully executed cost analysis of these alternatives is not within the scope of work. However, much like the subjective index items above, they can be compared with each other in order to obtain a rough framework for how the cost analysis should look in the future. When comparing Design 1 and "LOST", it is evident that the former will be the costlier of the two. Construction would be multifaceted as well as expensive when compared to the signal optimization and lane decrease of "LOST". While the analysis and implementation of these improvements are certainly not free, they have been estimated to only reach what is expected of Design 1. Therefore, Design 1 is expected to cost at least 2 to 3 times more than "LOST", making it a considerably the higher initial investment. However, despite the cost, when the scope of the project is considered alongside the performed Benefit/Cost analysis, Design 1 appears to

provide a higher benefit overall. With an emphasis on safety while still improving upon travel time, implementation of this design will make 3rd avenue a better travel way for pedestrians and vehicles alike.

Appendix A: Project Area Map

Project Area Map

The project is located in Huntington, West Virginia on Third Avenue, starting at 16th Street and ending at 20th Street, adjacent to Marshall University.

Appendix B: Calculations (Existing Conditions)

EXISTING CONDITIONS		
Intersection	**LOS**	**Intersection Delay (s)**
16th and 3rd Avenue	C	25.4
18th and 3rd Avenue	B	18.1
20th and 3rd Avenue	D	37.3

TRAVEL TIME VALUE	
$/hr	**$/s**
$12.00	$0.0033

DESIGN 1 CONDITIONS			
Intersection	**LOS**	**Intersection Delay (s)**	**Veh/hr**
16th and 3rd Avenue	C	29.2	2739
18th and 3rd Avenue	A	5.8	2607
20th and 3rd Avenue	D	39.2	3356

DESIGN 1 VS EXISTING			
Intersection	**Δ Intersection Delay (s)**	**Benefit/Cost ($/hr)**	**Total Benefit ($/hr)**
16th and 3rd Avenue	-3.8	-$34.69	$50.94
18th and 3rd Avenue	12.3	$106.89	
20th and 3rd Avenue	-1.9	-$21.25	

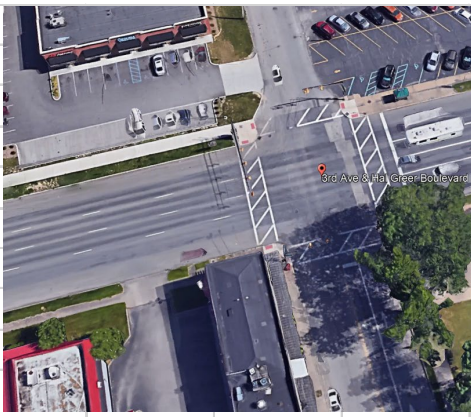
"LOST" CONDITIONS			
Intersection	**LOS**	**Intersection Delay (s)**	**Veh/hr**
16th and 3rd Avenue	B	16	2799
18th and 3rd Avenue	B	10.6	2542
20th and 3rd Avenue	C	34.1	3651

"LOST" VS EXISTING			
Intersection	**Δ Intersection Delay (s)**	**Benefit/Cost ($/hr)**	**Total Benefit ($/hr)**
16th and 3rd Avenue	9.4	$87.70	$190.20
18th and 3rd Avenue	7.5	$63.55	
20th and 3rd Avenue	3.2	$38.94	

CONDITION SCALE [1-10]			
	Safety Improvements	***Beautification***	***Vehicle Operating Cost***
Existing	2/10	5/10	6/10
Design 1	8/10	7/10	5/10
"LOST"	5/10	5/10	6/10

3rd Ave and 16th St.

Sheet #:	1
Observers:	Geocounts & MC
Date:	2019-10-28
Weather:	Foggy and Chilly
Time:	11:00-11:15am
Intersection Control:	Signalized
Where:	3rd Ave and 16th St.



Pedestrians				
16th South	16th North	3rd West	3rd East	Total
2	0	0	3	5

3rd Ave West								
	WBL	WBR	WBST	NBL	NBST	SBR	SBST	Total
Cars/Trucks	44	5	158	42	6	2	11	268
						Total @		268

Sheet #:	2
Observers:	Geocounts & MC
Date:	2019-10-28
Weather:	Foggy and Chilly
Time:	11:15-11:30am
Intersection Control:	Signalized
Where:	3rd Ave and 16th St.

Pedestrians				
16th South	16th North	3rd West	3rd East	Total
0	2	4	0	6

3rd Ave West								
	WBL	WBR	WBST	NBL	NBST	SBR	SBST	Total
Cars/Trucks	55	3	189	43	14	2	11	317
						Total @		317

Sheet #:	3
Observers:	Geocounts & MC
Date:	2019-10-28
Weather:	Foggy and Chilly
Time:	11:30-11:45am
Intersection Control:	Signalized
Where:	3rd Ave and 16th St.

Pedestrians				
16th South	16th North	3rd West	3rd East	Total
5	0	3	5	13

3rd Ave West								
	WBL	WBR	WBST	NBL	NBST	SBR	SBST	Total
Cars/Trucks	49	5	179	52	14	4	10	313
						Total @		313

Sheet #:	4
Observers:	Geocounts & MC
Date:	2019-10-28
Weather:	Foggy and Chilly
Time:	11:45am-12:00pm
Intersection Control:	Signalized
Where:	3rd Ave and 16th St.

Pedestrians				
16th South	16th North	3rd West	3rd East	Total
8	3	6	9	26

3rd Ave West								
	WBL	WBR	WBST	NBL	NBST	SBR	SBST	Total
Cars/Trucks	57	3	218	47	13	9	12	359
						Total @ Intersection		359

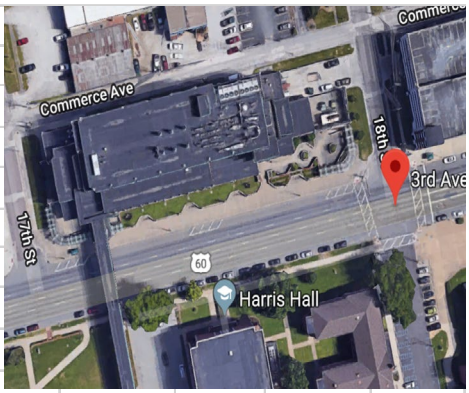
Design Factors			
$M_j * D_k$	1.21	K	0.12
HEF_i	15	D	1

AADT							
	WBL	WBR	WBST	NBL	NBST	SBR	SBST
Cars/Trucks	3720.75	290.4	13503.6	3339.6	853.05	308.55	798.6

DDHV							
	WBL	WBR	WBST	NBL	NBST	SBR	SBST
Cars/Trucks	446.49	34.848	1620.432	400.752	102.366	37.026	95.832

3rd Ave and 18th St.

Sheet #:	1
Observers:	JM & NW
Date:	2019-10-29
Weather:	Sunny
Time:	11:00-11:15am
Intersection Control:	Signalized
Where:	3rd Ave and 18th St.



Pedestrians				
3rd By Garage	18th from Plant	3rd by Bio-Tech	18th by Laidley Hall	Total
13	0	0	9	22

3rd Ave West								
	WBL	WBR	WBST	NBL	NBST	SBR	SBST	Total
Cars	2	6	156	2	0	10	1	177
Trucks	2	0	12	0	0	0	0	14
						Total @ Intersection		191

Sheet #:	2
Observers:	JM & NW
Date:	2019-10-29
Weather:	Sunny
Time:	11:15-11:30am
Intersection Control:	Signalized
Where:	3rd Ave and 18th St.

Pedestrians				
3rd By Garage	18th from Plant	3rd by Bio-Tech	18th by Laidley Hall	Total
16	18	4	9	47

3rd Ave West								
	WBL	WBR	WBST	NBL	NBST	SBR	SBST	Total
Cars	1	10	241	5	2	11	0	270
Trucks	0	0	17	1	0	0	0	18
						Total @		288

Sheet #:	3
Observers:	JM & NW
Date:	2019-10-29
Weather:	Sunny
Time:	11:30-11:45am
Intersection Control:	Signalized
Where:	3rd Ave and 18th St.

Pedestrians				
3rd By Garage	18th from Plant	3rd by Bio-Tech	18th by Laidley Hall	Total
6	10	4	19	39

3rd Ave West								
	WBL	WBR	WBST	NBL	NBST	SBR	SBST	Total
Cars	1	7	323	1	1	10	0	343
Trucks	1	0	19	0	0	0	0	20
						Total @		363

Sheet #:	4
Observers:	JM & NW
Date:	2019-10-29
Weather:	Sunny
Time:	11:45am-12:00pm
Intersection Control:	Signalized
Where:	3rd Ave and 18th St.

Pedestrians

3rd By Garage	18th from Plant	3rd by Bio-Tech	18th by Laidley Hall	Total
31	27	2	40	100

3rd Ave West

	WBL	WBR	WBST	NBL	NBST	SBR	SBST	Total
Cars	4	8	271	2	1	26	0	312
Trucks	0	0	12	0	0	0	0	12
						Total @ Intersection		324

Design Factors

$M_j * D_k$	1.21	K	0.12
HEF_i	15	D	1

AADT

	WBL	WBR	WBST	NBL	NBST	SBR	SBST
Cars	145.2	562.65	17986.65	181.5	72.6	1034.55	18.15
Trucks	54.45	0	1089	18.15	0	0	0

DDHV

	WBL	WBR	WBST	NBL	NBST	SBR	SBST
Cars	17.424	67.518	2158.398	21.78	8.712	124.146	2.178
Trucks	6.534	0	130.68	2.178	0	0	0

3rd Ave and 20th St.

Sheet #:	1
Observers:	MR, LS, & AT
Date:	2019-10-29
Weather:	Sunny
Time:	11:15am-11:30am
Intersection Control:	Signalized
Where:	3rd Ave and 20th St.

Pedestrians				
20th South	20th North	3rd West	3rd East	Total
3	2	4	0	9

3rd Ave West Bound								
	WBL	WBR	WBST	NBL	NBST	SBR	SBST	Total
Cars	64	6	197	54	17	6	19	363
Trucks	1	1	8	2	1	2	4	19
						Total @ Intersection		382

Sheet #:	2
Observers:	MR, LS, & AT
Date:	2019-10-29
Weather:	Sunny
Time:	11:30am-11:45am
Intersection Control:	Signalized
Where:	3rd Ave and 20th St.

Pedestrians				
20th South	20th North	3rd West	3rd East	Total
7	1	1	2	11

3rd Ave West Bound								
	WBL	WBR	WBST	NBL	NBST	SBR	SBST	Total
Cars	88	7	191	58	18	6	25	393
Trucks	0	2	8	0	3	0	1	14
						Total @		407

Sheet #:	3
Observers:	MR, LS, & AT
Date:	2019-10-29
Weather:	Sunny
Time:	11:45am-12:00pm
Intersection Control:	Signalized
Where:	3rd Ave and 20th St.

Pedestrians				
20th South	20th North	3rd West	3rd East	Total
11	1	1	1	14

3rd Ave West Bound								
	WBL	WBR	WBST	NBL	NBST	SBR	SBST	Total
Cars	76	5	201	66	28	4	13	393
Trucks	1	1	8	3	6	4	0	23
						Total @		416

Sheet #:	4
Observers:	MR, LS, & AT
Date:	2019-10-29
Weather:	Sunny
Time:	12:00pm-12:15pm
Intersection Control:	Signalized
Where:	3rd Ave and 20th St.

Pedestrians				
20th South	20th North	3rd West	3rd East	Total
11	4	7	6	28

3rd Ave West Bound								
	WBL	WBR	WBST	NBL	NBST	SBR	SBST	Total
Cars	85	5	207	82	21	6	41	447
Trucks	1	1	14	2	2	2	2	24
						Total @ Intersection		471

Design Factors			
$M_j * D_k$	1.21	K	0.12
HEF_i	15	D	1

AADT							
	WBL	WBR	WBST	NBL	NBST	SBR	SBST
Cars	5680.95	417.45	14447.4	4719	1524.6	399.3	1778.7
Trucks	54.45	90.75	689.7	127.05	217.8	145.2	127.05

DDHV							
	WBL	WBR	WBST	NBL	NBST	SBR	SBST
Cars	681.714	50.094	1733.688	566.28	182.952	47.916	213.444
Trucks	6.534	10.89	82.764	15.246	26.136	17.424	15.246

Jaywalkers

Jaywalkers	
Time:	**12-1:00pm**
3rd Ave Biotech-Bridge	47
3rd ENGR Building	70
3rd Ave Between Bball & Fat Pattys	13

Jaywalkers	
Time:	**12:30-1:30pm**
Between Byrd and Cam Center Bridges	67
Betweeen 20th St and Cam Center	28

Jaywalkers	
Time:	**1:30-2:30pm**
Crosswalk in front of WAEC	126
In between WAEC Crosswalk and 16th	59

Design Hourly Volume

Average Annual Daily Traffic, AADT = $\frac{Total\ Volume\ (One\ Year)}{365} * Mj * Dk * HEFi$

Directional Design Hourly Volume (DDHV) = AADT x K x D

Design Hourly Volume, DHV = $AADT\ * K$

Correction Factors K, D, HEF, M_j, D_k

Parameter	Description	Reference
D	% of traffic in peak direction	HCM, Exhibit 3-10
D_k	Day-of-week factor	HCM, Exhibit 3-3
HEF	Hourly expansion factor	HCM, Exhibit 3-5
K	% of ADDT during peak hour	HCM, Exhibit 3-9
M_j	Monthly factor	HCM, Exhibit 3-1
PHV	Peak hour volume	GeoCounts

Appendix C1: Synchro Calculations (Design Alternative 1)

NODE SETTINGS	
Node #	3
ATMS.now Controller ID	0
Import from ATMS.now:	Import
Export to ATMS.now:	Export
Zone:	A
X East (ft):	3215
Y North (ft):	-946
Z Elevation (ft):	0
Description	
Control Type	Pretimed
Cycle Length (s):	150.0
Lock Timings:	☐
Optimize Cycle Length:	Optimize
Optimize Splits:	Optimize
Actuated Cycle(s):	150.0
Natural Cycle(s):	90.0
Max v/c Ratio:	0.92
Intersection Delay (s):	39.2
Intersection LOS:	D
ICU:	0.78
ICU LOS:	D
Offset (s) :	8.0
Referenced to:	Begin of Green
Reference Phase:	2+6 - Unassigned
Coordination Mode:	Fixed
Master Intersection:	☐
Yield Point:	Single
Mandatory Stop On Yellow:	☐

TIMING SETTINGS	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	PED	HOLD
Lanes and Sharing (#RL)													—	—
Traffic Volume (vph)	0	0	0	687	1816	61	290	208	0	0	229	65	—	—
Future Volume (vph)	0	0	0	687	1816	61	290	208	0	0	229	65	0	2
Turn Type	—	—	—	Perm	—	—	Perm	—	—	—	—	Perm	—	—
Protected Phases	—	—	—		6	—		8	—	—	4			
Permitted Phases	—	—	—	6		—	8		—	—		4	—	—
Permitted Flashing Yellow	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Detector Phases	—	—	—	6	6	—	8	8	—	—	4	4	—	—
Switch Phase	—	—	—	0	0	—	0	0	—	—	0	0	—	—
Leading Detector (ft)	—	—	—	—	100	—	20	100	—	—	100	20	—	—
Trailing Detector (ft)	—	—	—	—	0	—	0	0	—	—	0	0	—	—
Minimum Initial (s)	—	—	—	5.0	5.0	—	5.0	5.0	—	—	5.0	5.0	—	—
Minimum Split (s)	—	—	—	22.5	22.5	—	40.0	40.0	—	—	30.9	30.9	—	—
Total Split (s)	—	—	—	82.0	82.0	—	68.0	68.0	—	—	68.0	68.0	—	—
Yellow Time (s)	—	—	—	3.5	3.5	—	3.3	3.3	—	—	3.3	3.3	—	—
All-Red Time (s)	—	—	—	1.0	1.0	—	1.6	1.6	—	—	1.6	1.6	—	—
Lost Time Adjust (s)	—	0.0	—	—	0.0	0.0	0.0	0.0	—	—	0.0	0.0	—	—
Lagging Phase?	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Allow Lead/Lag Optimize?	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Recall Mode	—	—	—	Max	Max	—	Max	Max	—	—	Max	Max	—	—
Speed limit (mph)	—	30	—	—	30	—	30	25	—	—	25	—	—	25
Actuated Effct. Green (s)	—	—	—	—	77.5	—	63.1	63.1	—	—	63.1	63.1	—	—
Actuated g/C Ratio	—	—	—	—	0.52	—	0.42	0.42	—	—	0.42	0.42	—	—
Volume to Capacity Ratio	—	—	—	—	0.92	—	0.83	0.15	—	—	0.32	0.11	—	—
Control Delay (s)	—	—	—	—	39.2	—	58.7	27.3	—	—	30.5	22.9		—
Queue Delay (s)	—	—	—	—	0.0	—	0.0	0.0	—	—	0.0	0.0	—	—
Total Delay (s)	—	—	—	—	39.2	—	58.7	27.3	—	—	30.5	22.9	—	—
Level of Service	—	—	—	—	D	—	E	C	—	—	C	C	—	—
Approach Delay (s)	—	—	—	—	39.2	—	—	45.6	—	—	28.8	—	—	—
Approach LOS	—	—	—	—	D	—	—	D	—	—	C	—	—	—
Queue Length 50th (ft)	—	—	—	—	710	—	272	71	—	—	162	35	—	—
Queue Length 95th (ft)	—	—	—	—	763	—	#451	101	—	—	232	70	—	—
Stops (vph)	—	—	—	—	2258	—	248	124	—	—	149	33	—	—
Fuel Used (g/hr)	—	—	—	—	40	—	7	3	—	—	3	1	—	—

Figure 1. 3rd Ave & 20th St

NODE SETTINGS	
Node #	6
ATMS.now Controller ID	0
Import from ATMS.now:	Import
Export to ATMS.now:	Export
Zone:	B
X East (ft):	2110
Y North (ft):	-1147
Z Elevation (ft):	0
Description	
Control Type	Pretimed
Cycle Length (s):	150.0
Lock Timings:	☐
Optimize Cycle Length:	Optimize
Optimize Splits:	Optimize
Actuated Cycle(s):	150.0
Natural Cycle(s):	90.0
Max v/c Ratio:	0.74
Intersection Delay (s):	5.8
Intersection LOS:	A
ICU:	0.78
ICU LOS:	D
Offset (s) :	1.0
Referenced to:	Begin of Green
Reference Phase:	2+6 - Unassigned
Coordination Mode:	Fixed
Master Intersection:	☐
Yield Point:	Single
Mandatory Stop On Yellow:	☐

TIMING SETTINGS	EBL	EBT	EBR	EBR2	WBL2	WBL	WBT	WBR	NBL2	NBL	NBT	NBR	SBL	SBT	SBR	SBR2	NEL2	NEL	NER	NER2	PED	HOLD
Lanes and Sharing (#RL)																					—	—
Traffic Volume (vph)	0	0	0	0	0	1587	793	68	24	0	9	0	0	2	0	124	0	0	0	0	—	—
Future Volume (vph)	0	0	0	0	0	1587	793	68	24	0	9	0	0	2	0	124	0	0	0	0	—	—
Turn Type	—	—	—	—	—	Perm	—	Perm	Perm	—	—	—	—	—	—	—	—	—	—	—	—	—
Protected Phases	—	—	—	—	—		6			—	8	—	—	4	—	—	—	—	—	—		
Permitted Phases	—	—	—	—	—	6		6	8	—		—	—		—	—	—	—	—	—	—	—
Permitted Flashing Yellow	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Detector Phases	—	—	—	—	—	6	6	6	8	—	8	—	—	4	—	—	—	—	—	—	—	—
Switch Phase	—	—	—	—	—	0	0	0	0	—	0	—	—	0	—	—	—	—	—	—	—	—
Leading Detector (ft)	—	—	—	—	—	20	100	20	—	—	100	—	—	100	—	—	—	—	—	—	—	—
Trailing Detector (ft)	—	—	—	—	—	0	0	0	—	—	0	—	—	0	—	—	—	—	—	—	—	—
Minimum Initial (s)	—	—	—	—	—	5.0	5.0	5.0	29.6	—	29.6	—	—	29.6	—	—	—	—	—	—	—	—
Minimum Split (s)	—	—	—	—	—	22.5	22.5	22.5	35.0	—	35.0	—	—	35.0	—	—	—	—	—	—	—	—
Total Split (s)	—	—	—	—	—	114.0	114.0	114.0	36.0	—	36.0	—	—	36.0	—	—	—	—	—	—	—	—
Yellow Time (s)	—	—	—	—	—	3.5	3.5	3.5	3.0	—	3.0	—	—	3.0	—	—	—	—	—	—	—	—
All-Red Time (s)	—	—	—	—	—	1.0	1.0	1.0	2.4	—	2.4	—	—	2.4	—	—	—	—	—	—	—	—
Lost Time Adjust (s)	—	0.0	—	—	0.0	0.0	0.0	0.0	—	—	0.0	0.0	—	0.0	—	—	—	—	—	—	—	—
Lagging Phase?	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Allow Lead/Lag Optimize?	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Recall Mode	—	—	—	—	—	Max	Max	Max	Max	—	Max	—	—	Max	—	—	—	—	—	—	—	—
Speed limit (mph)	—	30	—	—	30	—	30	25	—	—	25	—	—	25	—	—	—	30	—	—	—	—
Actuated Effct. Green (s)	—	—	—	—	—	109.5	109.5	109.5	—	—	30.6	—	—	30.6	—	—	—	—	—	—	—	—
Actuated g/C Ratio	—	—	—	—	—	0.73	0.73	0.73	—	—	0.20	—	—	0.20	—	—	—	—	—	—	—	—
Volume to Capacity Ratio	—	—	—	—	—	0.74	0.68	0.07	—	—	0.12	—	—	0.33	—	—	—	—	—	—	—	—
Control Delay (s)	—	—	—	—	—	4.9	5.3	0.1	—	—	50.2	—	—	10.1	—	—	—	—	—	—	—	—
Queue Delay (s)	—	—	—	—	—	0.0	0.1	0.0	—	—	0.0	—	—	0.0	—	—	—	—	—	—	—	—
Total Delay (s)	—	—	—	—	—	5.0	5.5	0.1	—	—	50.2	—	—	10.1	—	—	—	—	—	—	—	—
Level of Service	—	—	—	—	—	A	A	A	—	—	D	—	—	B	—	—	—	—	—	—	—	—
Approach Delay (s)	—	—	—	—	—	—	5.0	—	—	—	50.2	—	—	10.1	—	—	—	—	—	—	—	—
Approach LOS	—	—	—	—	—	—	A	—	—	—	D	—	—	B	—	—	—	—	—	—	—	—
Queue Length 50th (ft)	—	—	—	—	—	142	135	0	—	—	29	—	—	2	—	—	—	—	—	—	—	—
Queue Length 95th (ft)	—	—	—	—	—	139	m137	m0	—	—	63	—	—	60	—	—	—	—	—	—	—	—
Stops (vph)	—	—	—	—	—	253	124	0	—	—	27	—	—	17	—	—	—	—	—	—	—	—
Fuel Used (g/hr)	—	—	—	—	—	17	8	1	—	—	1	—	—	1	—	—	—	—	—	—	—	—

Figure 2. 3rd Ave & 18th St

NODE SETTINGS	
Node #	9
ATMS.now Controller ID:	0
Import from ATMS.now:	Import
Export to ATMS.now:	Export
Zone:	C
X East (ft):	559
Y North (ft):	-1534
Z Elevation (ft):	0
Description	
Control Type	Pretimed
Cycle Length (s):	150.0
Lock Timings:	☐
Optimize Cycle Length:	Optimize
Optimize Splits:	Optimize
Actuated Cycle(s):	150.0
Natural Cycle(s):	130.0
Max v/c Ratio:	0.96
Intersection Delay (s):	29.2
Intersection LOS:	C
ICU:	1.07
ICU LOS:	G
Offset (s):	45.0
Referenced to:	Begin of Green
Reference Phase:	2+6 - Unassigned
Coordination Mode:	Fixed
Master Intersection:	☐
Yield Point:	Single
Mandatory Stop On Yellow:	☐

TIMING SETTINGS	EBL2	EBL	EBT	EBR	WBL	WBT	WBR	WBR2	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SWL2	SWL	SWR	SWR2	PED	HOLD
Lanes and Sharing (#RL)																					–	–
Traffic Volume (vph)	0	0	0	0	447	1621	0	0	401	102	0	0	0	0	96	37	0	0	35	0	–	–
Future Volume (vph)	0	0	0	0	447	1621	0	0	401	102	0	0	0	0	96	37	0	0	35	0	–	–
Turn Type	–	–	–	–	Perm	–	–	–	pm+pt	–	–	–	–	–	–	–	–	–	Perm	–	–	–
Protected Phases	–	–	–	–		6	–	–	3	8	–	–	–	–	4	–	–	–		–		
Permitted Phases	–	–	–	–	6		–	–	8		–	–	–	–		–	–	–	4	–	–	–
Permitted Flashing Yellow	–	–	–	–	–	–	–	–	☐	–	–	–	–	–	–	–	–	–	–	–	–	–
Detector Phases	–	–	–	–	6	6	–	–	3	8	–	–	–	–	4	–	–	–	4	–	–	–
Switch Phase	–	–	–	–	0	0	–	–	0	0	–	–	–	–	0	–	–	–	0	–	–	–
Leading Detector (ft)	–	–	–	–	–	100	–	–	20	100	–	–	–	–	100	–	–	–	20	–	–	–
Trailing Detector (ft)	–	–	–	–	–	0	–	–	0	0	–	–	–	–	0	–	–	–	0	–	–	–
Minimum Initial (s)	–	–	–	–	5.0	5.0	–	–	5.0	5.0	–	–	–	–	5.0	–	–	–	5.0	–	–	–
Minimum Split (s)	–	–	–	–	30.0	30.0	–	–	20.0	25.0	–	–	–	–	25.0	–	–	–	25.0	–	–	–
Total Split (s)	–	–	–	–	105.0	105.0	–	–	20.0	45.0	–	–	–	–	25.0	–	–	–	25.0	–	–	–
Yellow Time (s)	–	–	–	–	3.5	3.5	–	–	3.3	3.3	–	–	–	–	3.3	–	–	–	3.3	–	–	–
All-Red Time (s)	–	–	–	–	1.0	1.0	–	–	1.6	1.6	–	–	–	–	1.6	–	–	–	1.6	–	–	–
Lost Time Adjust (s)	–	0.0	–	–	–	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	0.0	0.0	–	–	–	0.0	–	–	–
Lagging Phase?	–	–	–	–	–	–	–	–	☐	–	–	–	–	–	☑	–	–	–	☑	–	–	–
Allow Lead/Lag Optimize?	–	–	–	–	–	–	–	–	☑	–	–	–	–	–	☑	–	–	–	☑	–	–	–
Recall Mode	–	–	–	–	Max	Max	–	–	Max	Max	–	–	–	–	Max	–	–	–	Max	–	–	–
Speed limit (mph)	–	30	30	–	30	35	30	25	–	25	25	–	–	25	25	–	–	30	–	–	–	–
Actuated Effct. Green (s)	–	–	–	–	–	100.5	–	–	40.1	40.1	–	–	–	–	20.1	–	–	–	20.1	–	–	–
Actuated g/C Ratio	–	–	–	–	–	0.67	–	–	0.27	0.27	–	–	–	–	0.13	–	–	–	0.13	–	–	–
Volume to Capacity Ratio	–	–	–	–	–	0.96	–	–	0.83	0.83	–	–	–	–	0.30	–	–	–	0.19	–	–	–
Control Delay (s)	–	–	–	–	–	17.2	–	–	71.4	70.4	–	–	–	–	47.7	–	–	–	73.0	–	–	–
Queue Delay (s)	–	–	–	–	–	0.0	–	–	0.0	0.0	–	–	–	–	0.0	–	–	–	0.0	–	–	–
Total Delay (s)	–	–	–	–	–	17.2	–	–	71.4	70.4	–	–	–	–	47.7	–	–	–	73.0	–	–	–
Level of Service	–	–	–	–	–	B	–	–	E	E	–	–	–	–	D	–	–	–	E	–	–	–
Approach Delay (s)	–	–	–	–	–	17.2	–	–	–	70.9	–	–	–	–	47.7	–	–	73.0	–	–	–	–
Approach LOS	–	–	–	–	–	B	–	–	–	E	–	–	–	–	D	–	–	E	–	–	–	–
Queue Length 50th (ft)	–	–	–	–	–	327	–	–	240	254	–	–	–	–	53	–	–	–	38	–	–	–
Queue Length 95th (ft)	–	–	–	–	–	#368	–	–	#393	#409	–	–	–	–	89	–	–	–	m59	–	–	–
Stops (vph)	–	–	–	–	–	999	–	–	203	216	–	–	–	–	93	–	–	–	33	–	–	–
Fuel Used (g/hr)	–	–	–	–	–	38	–	–	5	6	–	–	–	–	2	–	–	–	1	–	–	–

Figure 3. 3rd Ave & 16th St

Appendix C2: Synchro Calculations (Design Alternative 2)

NODE SETTINGS	
Node #	3
ATMS.now Controller ID	0
Import from ATMS.now:	Import
Export to ATMS.now:	Export
Zone:	
X East (ft):	3215
Y North (ft):	-946
Z Elevation (ft):	0
Description	
Control Type	Pretimed
Cycle Length (s):	100.0
Lock Timings:	☐
Optimize Cycle Length:	Optimize
Optimize Splits:	Optimize
Actuated Cycle 90th (s):	100.0
Actuated Cycle 70th (s):	100.0
Actuated Cycle 50th (s):	100.0
Actuated Cycle 30th (s):	100.0
Actuated Cycle 10th (s):	100.0
Natural Cycle(s):	90.0
Max v/c Ratio:	0.91
Intersection Delay (s):	34.1
Intersection LOS:	C
ICU:	0.87
ICU LOS:	E
Offset (s) :	84.0
Referenced to:	Begin of Green
Reference Phase:	2 - WBTL
Coordination Mode:	Fixed
Master Intersection:	☐
Yield Point:	Single
Mandatory Stop On Yellow:	☐

PHASING SETTINGS	2-WBTL	3-NBL	4-SBT	8-NBTL
Minimum Initial (s)	5.0	5.0	5.0	5.0
Minimum Split (s)	40.0	20.0	20.0	40.0
Maximum Split (s)	54.0	26.0	20.0	46.0
Yellow Time (s)	3.3	3.3	3.3	3.3
All-Red Time (s)	1.4	1.6	1.6	1.6
Lagging Phase?	—	☐	☑	—
Allow Lead/Lag Optimize?	—	☑	☑	—
Optimize Phs Weights - Delays	1.0	1.0	1.0	1.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0
Minimum Gap (s)	3.0	3.0	3.0	3.0
Time Before Reduce (s)	0.0	0.0	0.0	0.0
Time To Reduce (s)	0.0	0.0	0.0	0.0
Recall Mode	Max	Max	Max	Max
Pedestrian Phase	☑	☐	☑	☑
Walk Time (s)	7.0	—	7.0	7.0
Flash Dont Walk (s)	11.0	—	11.0	11.0
Pedestrian Calls (#/hr)	0	—	0	0
Dual Entry?	☑	☐	☑	☑
Fixed Force Off?	☑	☑	☑	☑
90th %ile Green Time (s)	49 cd	21 mr	15 pd	41 mr
70th %ile Green Time (s)	49 cd	21 mr	15 pd	41 mr
50th %ile Green Time (s)	49 cd	21 mr	15 pd	41 mr
30th %ile Green Time (s)	49 cd	21 mr	15 pd	41 mr
10th %ile Green Time (s)	49 cd	21 mr	15 pd	41 mr

Figure 4. 3rd Ave & 20th St

NODE SETTINGS	
Node #	6
ATMS.now Controller ID	0
Import from ATMS.now:	Import
Export to ATMS.now:	Export
Zone:	
X East (ft):	2198
Y North (ft):	-1167
Z Elevation (ft):	0
Description	
Control Type	Pretimed
Cycle Length (s):	100.0
Lock Timings:	☐
Optimize Cycle Length:	Optimize
Optimize Splits:	Optimize
Actuated Cycle 90th (s):	100.0
Actuated Cycle 70th (s):	100.0
Actuated Cycle 50th (s):	100.0
Actuated Cycle 30th (s):	100.0
Actuated Cycle 10th (s):	100.0
Natural Cycle(s):	80.0
Max v/c Ratio:	0.85
Intersection Delay (s):	10.6
Intersection LOS:	B
ICU:	0.79
ICU LOS:	D
Offset (s) :	92.0
Referenced to:	Begin of Green
Reference Phase:	2 - WBTL
Coordination Mode:	Fixed
Master Intersection:	☐
Yield Point:	Single
Mandatory Stop On Yellow:	☐

PHASING SETTINGS	2-WBTL	4-SBT	8-NBTL
Minimum Initial (s)	40.0	29.6	29.6
Minimum Split (s)	45.0	35.0	35.0
Maximum Split (s)	65.0	35.0	35.0
Yellow Time (s)	3.3	3.0	3.0
All-Red Time (s)	1.4	2.4	2.4
Lagging Phase?	—	—	—
Allow Lead/Lag Optimize?	—	—	—
Optimize Phs Weights - Delays	1.0	1.0	1.0
Vehicle Extension (s)	3.0	3.0	3.0
Minimum Gap (s)	3.0	3.0	3.0
Time Before Reduce (s)	0.0	0.0	0.0
Time To Reduce (s)	0.0	0.0	0.0
Recall Mode	Max	Max	Max
Pedestrian Phase	☑	☑	☑
Walk Time (s)	7.0	7.0	7.0
Flash Dont Walk (s)	11.0	11.0	11.0
Pedestrian Calls (#/hr)	0	0	0
Dual Entry?	☑	☑	☑
Fixed Force Off?	☑	☑	☑
90th %ile Green Time (s)	60 cd	30 mr	30 mr
70th %ile Green Time (s)	60 cd	30 mr	30 mr
50th %ile Green Time (s)	60 cd	30 mr	30 mr
30th %ile Green Time (s)	60 cd	30 mr	30 mr
10th %ile Green Time (s)	60 cd	30 mr	30 mr

Figure 5. 3rd Ave & 18th St

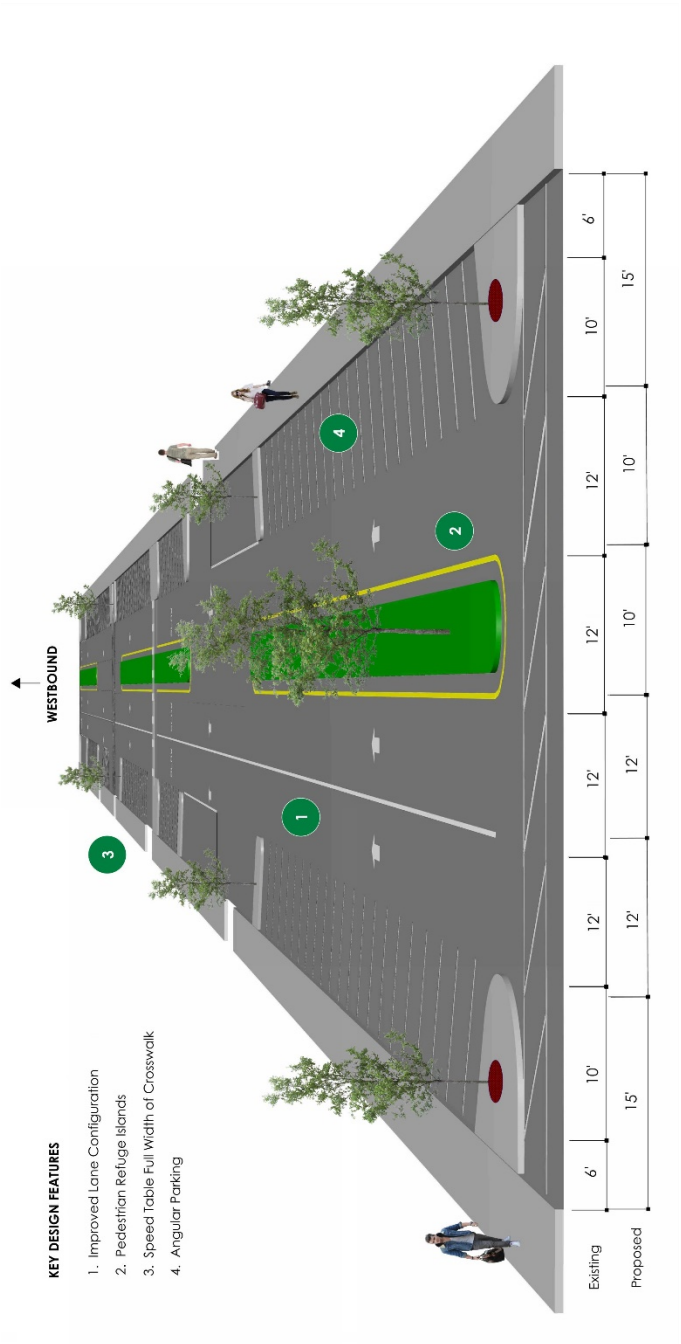
NODE SETTINGS	
Node #	9
ATMS.now Controller ID	0
Import from ATMS.now:	Import
Export to ATMS.now:	Export
Zone:	C
X East (ft):	559
Y North (ft):	-1534
Z Elevation (ft):	0
Description	
Control Type	Pretimed
Cycle Length (s):	150.0
Lock Timings:	☐
Optimize Cycle Length:	Optimize
Optimize Splits:	Optimize
Actuated Cycle 90th (s):	150.0
Actuated Cycle 70th (s):	150.0
Actuated Cycle 50th (s):	150.0
Actuated Cycle 30th (s):	150.0
Actuated Cycle 10th (s):	150.0
Natural Cycle(s):	130.0
Max v/c Ratio:	0.96
Intersection Delay (s):	29.2
Intersection LOS:	C
ICU:	1.07
ICU LOS:	G
Offset (s) :	45.0
Referenced to:	Begin of Green
Reference Phase:	2+6 - Unassigned
Coordination Mode:	Fixed
Master Intersection:	☐
Yield Point:	Single
Mandatory Stop On Yellow:	☐

PHASING SETTINGS	3-NBL	4-SBT	6-WBTL	8-NBTL
Minimum Initial (s)	5.0	5.0	5.0	5.0
Minimum Split (s)	20.0	25.0	30.0	25.0
Maximum Split (s)	20.0	25.0	105.0	45.0
Yellow Time (s)	3.3	3.3	3.5	3.3
All-Red Time (s)	1.6	1.6	1.0	1.6
Lagging Phase?	☐	☑	—	—
Allow Lead/Lag Optimize?	☑	☑	—	—
Optimize Phs Weights - Delays	1.0	1.0	1.0	1.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0
Minimum Gap (s)	3.0	3.0	3.0	3.0
Time Before Reduce (s)	0.0	0.0	0.0	0.0
Time To Reduce (s)	0.0	0.0	0.0	0.0
Recall Mode	Max	Max	Max	Max
Pedestrian Phase	☐	☑	☑	☑
Walk Time (s)	—	7.0	7.0	7.0
Flash Dont Walk (s)	—	11.0	11.0	11.0
Pedestrian Calls (#/hr)	—	0	0	0
Dual Entry?	☐	☑	☑	☑
Fixed Force Off?	☑	☑	☑	☑
90th %ile Green Time (s)	15 mi	20 mi	101 cd	40 mi
70th %ile Green Time (s)	15 mi	20 mi	101 cd	40 mi
50th %ile Green Time (s)	15 mi	20 mi	101 cd	40 mi
30th %ile Green Time (s)	15 mi	20 mi	101 cd	40 mi
10th %ile Green Time (s)	15 mi	20 mi	101 cd	40 mi

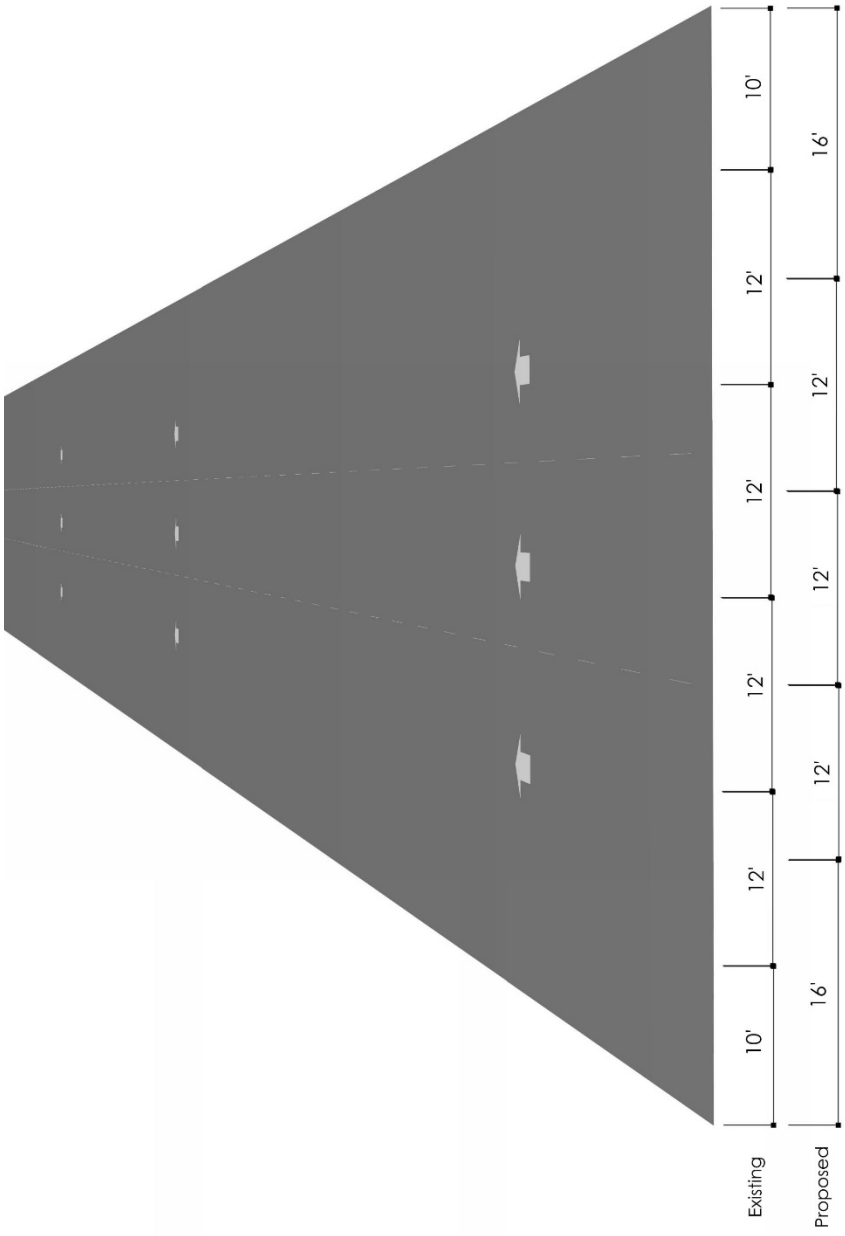
Figure 6. 3rd Ave & 16th St

Appendix D: Conceptual Typical Sections

Design Alternative 1



Design Alternative 2



END OF REPORT