
Technical Memorandum

TO: Hoang Hong, NDOT **DATE:** September 21, 2012

FROM: John Karachepone, Jacobs

SUBJECT: USA Parkway – Traffic Operations Analysis, Roundabout Option

COPIES: Pedro Rodriguez, NDOT; Bryan Gant, Jacobs; Randy Travis, NDOT

1. INTRODUCTION

The “USA Parkway Traffic Operations Analysis Memorandum” dated August 28, 2012, evaluated the traffic operational impacts of the USA Parkway extension on the existing facilities in the region. It also proposed geometry and traffic control for the new facility and proposed improvements to geometry and traffic control for existing facilities to ensure that these facilities operate at/better than NDOT’s desired LOS thresholds. The “USA Parkway Traffic Operations Analysis Memorandum” was approved by NDOT on September 05, 2012 (see Appendix A Addendum 1).

The “USA Parkway Traffic Operations Analysis Memorandum” determined the performance of the intersection of USA Parkway and US 50 for both the opening year 2017 and the design year 2037. For the USA Parkway and US 50 intersection, different intersection geometries and traffic control options (stop-control, signalization) were explored and the performance of each option was analyzed. At the end of the analyses, a signalized intersection (High-T for a T-intersection configuration and conventional for a 4-legged intersection configuration) at USA Parkway and US 50 was determined to be the best choice, both in terms of safety and operational efficiency.

In addition to the options explored in the “USA Parkway Traffic Operations Analysis Memorandum”, the project team wished to explore the option of a roundabout at the USA Parkway and US 50 intersection. Hence, the performance of a roundabout at the USA Parkway and US 50 intersection was evaluated for both the opening year 2017 and the design year 2037. This addendum to the “USA Parkway Traffic Operations Analysis Memorandum”, documents the results of this analysis.

This technical memorandum reports the traffic operations analyses for the roundabout option for the USA Parkway and US 50 intersection for the following:

- Opening Year 2017 Build Alternative
- Design Year 2037 Build Alternative

A comparison of the performance of the roundabout option with that of other traffic control options is also provided.

2. TECHNICAL GUIDANCE AND TRAFFIC ANALYSIS TOOLS

The analyses documented in this memorandum were completed according to the following technical documents and guidelines:

- Highway Capacity Manual (HCM), Transportation Research Board, 2010
- A Policy on Geometric Design of Highways and Streets, AASHTO, 2011
- Manual on Uniform Traffic Control Devices, FHWA, 2009
- Roundabouts: An Informational Guide, National Cooperative Highway Research Program (NCHRP) Report 672, 2010

In addition, the analyses were conducted consistent with the approved “USA Parkway Traffic Analysis Methodology”, the “USA Parkway Traffic Forecast Memorandum” and the “USA Parkway Traffic Operations Analysis Memorandum”.

Highway Capacity Software (HCS) 2010 was used for the analyses documented in this memorandum.

3. ANALYSIS METHODOLOGY & ASSUMPTIONS

The traffic operations analyses documented in this memorandum were conducted with the following general methodology/assumptions:

- Analysis periods are the AM and PM design hours.
- Peak Hour Factor of 0.90 was used as per the approved “USA Parkway Traffic Analysis Methodology Memorandum”.
- Peak hour truck percentage of 12% was used for USA Parkway and a peak hour truck percentage of 6% was used for US 50, as per the approved “USA Parkway Traffic Forecast Memorandum”.
- Analysis of the roundabout intersections was completed using HCS 2010, following HCM 2010 methodology.

As per the approved “USA Parkway Traffic Analysis Methodology”, LOS thresholds are defined as:

- HCM LOS D or better for the signalized intersection of USA Parkway at US 50. LOS C is desired for this intersection.
- LOS E or better for each movement at the intersection.
- LOS D or better for the overall (intersection) roundabout at USA Parkway at US 50. LOS E or better for each lane of the roundabout.
- Intersection V/C, including each movement, less than 1.0.

In addition, the methodology and assumptions documented in the “USA Parkway Traffic Operations Analysis Memorandum” corresponding to the analysis of signalized intersections also apply.

4. OPENING YEAR 2017 ANALYSIS

HCM LOS criteria for signalized and unsignalized intersections are shown in Table 4-1 Addendum 1. HCM LOS criteria for roundabouts are shown in Table 4-2 Addendum 1.

Table 4-1 Addendum 1: HCM LOS Criteria for Signalized and Unsignalized Intersections

LOS	Control Delay per Vehicle (in seconds)	
	Signalized Intersections	Unsignalized Intersections
A	0-10	0-10
B	>10-20	>10-15
C	>20-35	>15-25
D	>35-55	>25-35
E	>55-80	>35-50
F	>80	>50

Source: Highway Capacity Manual 2010, Transportation Research Board

Table 4-2 Addendum 1: HCM LOS Criteria for Roundabouts

LOS	Control Delay per Vehicle (in seconds)
A	0-10
B	>10-15
C	>15-25
D	>25-35
E	>35-50
F	>50

Source: Highway Capacity Manual 2010, Transportation Research Board

Figure 4-1 Addendum 1 shows the opening year 2017 peak hour volumes and Figure 4-2 Addendum 1 shows the opening year 2017 intersection turning movement volumes.

Sections 4.1 and 4.2 document the analyses corresponding to the T-intersection configuration and the 4-legged intersection configuration at the USA Parkway and US 50 intersection.

Figure 4-1 Addendum 1: Year 2017 Peak Hour Volumes (Build Alternative)

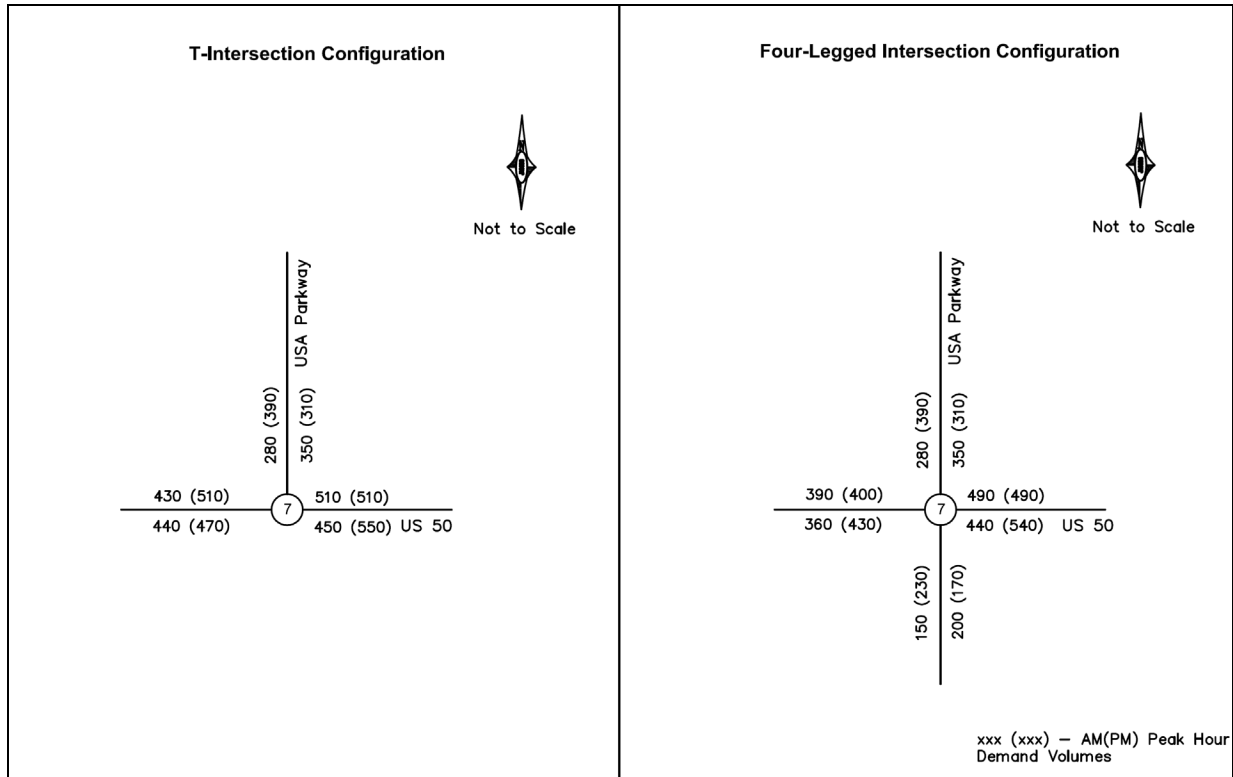
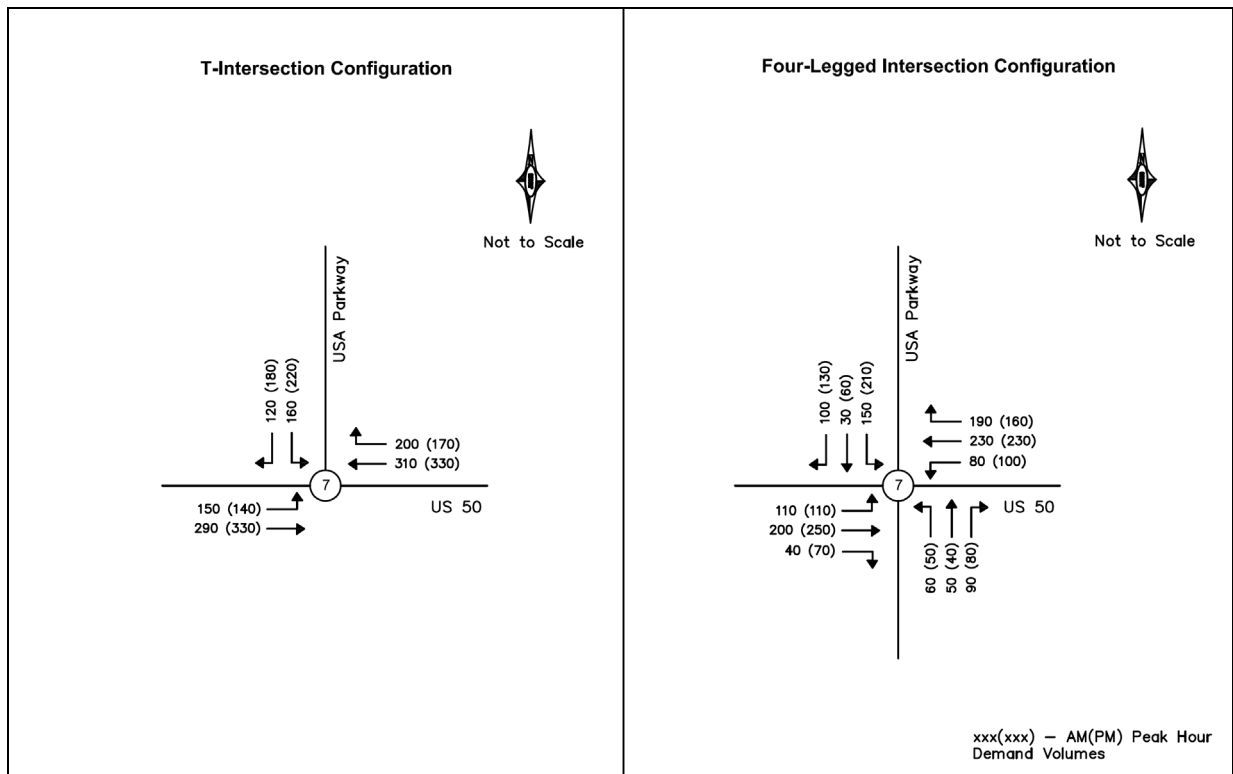


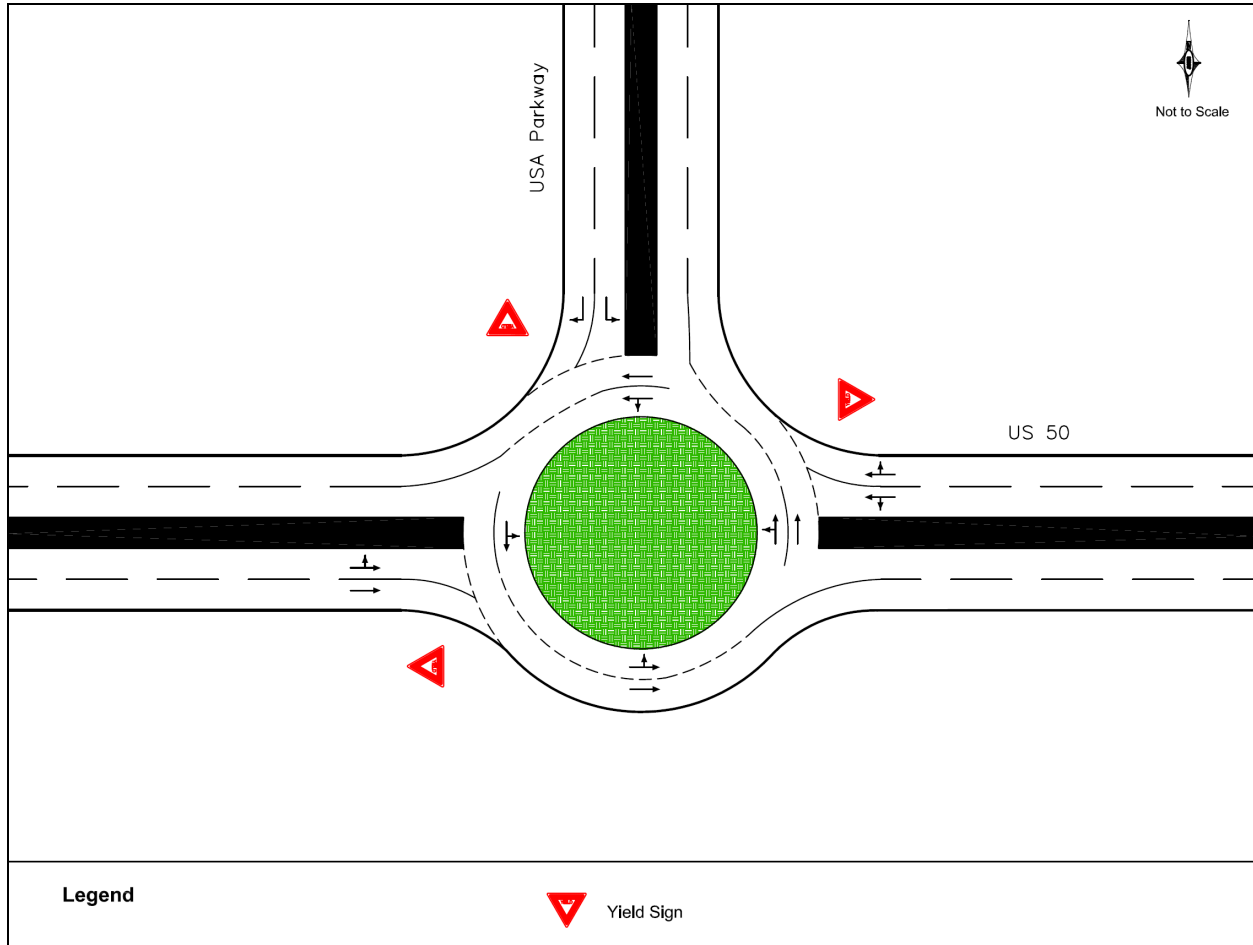
Figure 4-2 Addendum 1: Year 2017 Intersection Turning Movement Volumes (Build Alternative)



4.1. T-Intersection

The proposed geometry and traffic control for a roundabout at the USA Parkway and US 50 intersection (T-intersection) is shown in Figure 4-3 Addendum 1.

Figure 4-3 Addendum 1: Year 2017 Proposed Geometry and Control at the USA Parkway/US 50 Intersection (T-Intersection)



Note: Conceptual illustration for ease of understanding only.

Analysis of the roundabout intersection was completed using HCS 2010, following HCM 2010 methodology. The results of the roundabout intersection traffic operations analysis are shown in Table 4-3 Addendum 1. Table 4-3 Addendum 1 gives the Delay, LOS and V/C for the worst lane of the roundabout as well as the overall intersection (roundabout). HCS analysis worksheets are provided in Appendix B 1 Addendum 1.

Table 4-3 Addendum 1 also gives the results corresponding to a signalized High-T and a stop-controlled High-T intersection at USA Parkway and US 50. The analyses of these signalized and stop-controlled High-T options were previously documented in the “USA Parkway Traffic Operations Analysis Memorandum”.

Table 4-3 Addendum 1: Year 2017 - USA Parkway and US 50 (T-Intersection) - Analysis Results

Traffic Control	Reported Performance Measures Correspond to	AM Peak Hour			PM Peak Hour		
		Control Delay (s)	HCM LOS	V/C	Control Delay (s)	HCM LOS	V/C
Roundabout	Worst lane by delay	7.3	A	0.30	8.7	A	0.32
	Overall intersection	7.0	A	0.32*	7.7	A	0.34*
Signal (High-T)	Worst movement by delay	15.7	B	0.50	16.9	B	0.68
	Overall intersection	15.4	B	0.50*	15.8	B	0.68*
Stop (High-T)	Worst movement by delay	27.0	D	0.53	38.1	E	0.72

* HCM 2010 methodology does not provide an overall intersection V/C (HCM critical V/C). The highest lane/movement V/C for the intersection is reported as the V/C for the overall intersection.

Source: Jacobs, 2012

From Table 4-3 Addendum 1, it can be seen that, with the roundabout option, the overall intersection is anticipated to operate at LOS equal to or better than LOS D during both the AM and PM peak periods. In addition, the worst lane of the USA Parkway and US 50 intersection is anticipated to operate at LOS equal to or better than LOS E during both the AM and PM peak periods. V/C for each lane is also less than 1. It can also be seen that, the roundabout option is anticipated to result in lower delays compared to the signalized High-T and the stop-controlled High-T options.

Figure 4-4 Addendum 1 and Figure 4-5 Addendum 1 illustrate the comparative operational performance of the roundabout option against the signalized High-T option and the stop-controlled High-T option graphically. Figure 4-4 Addendum 1 compares the worst lane delay of the roundabout with that of the worst movement delay of the signalized and stop-controlled intersection. Figure 4-5 Addendum 1 compares the overall intersection delay of the roundabout with that of the overall intersection delay of the signalized intersection.

Figure 4-4 Addendum 1: Year 2017 - USA Parkway and US 50 (T-Intersection) - Analysis Results (Comparison of Worst Movement/Lane Delay)

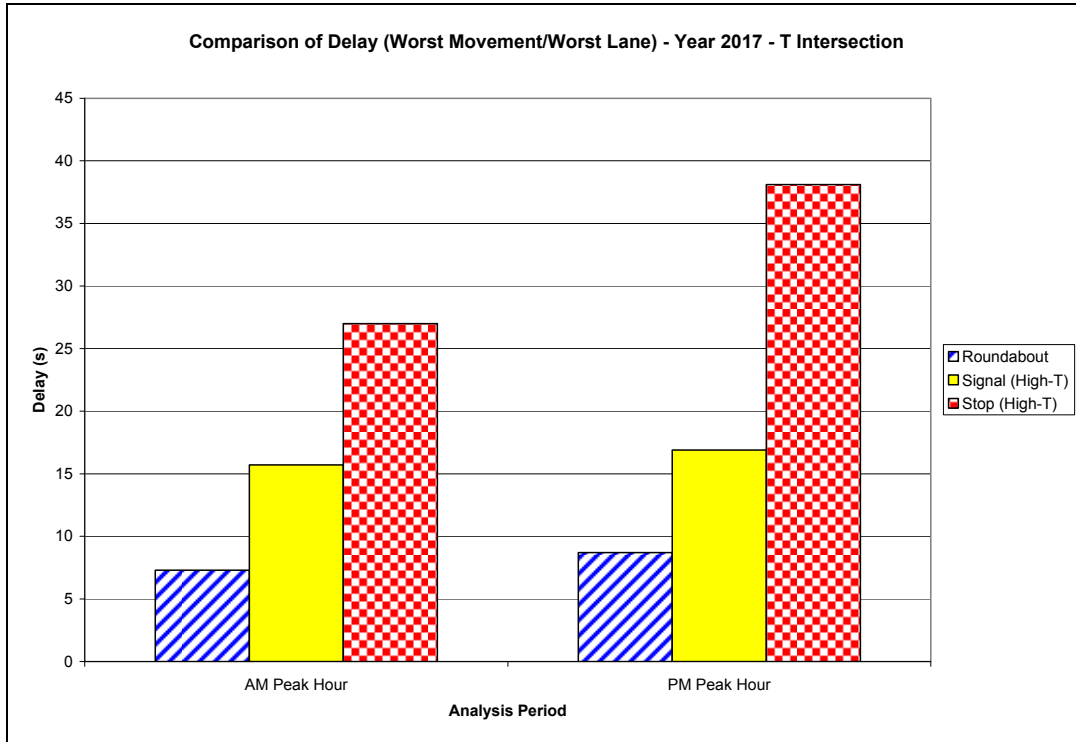
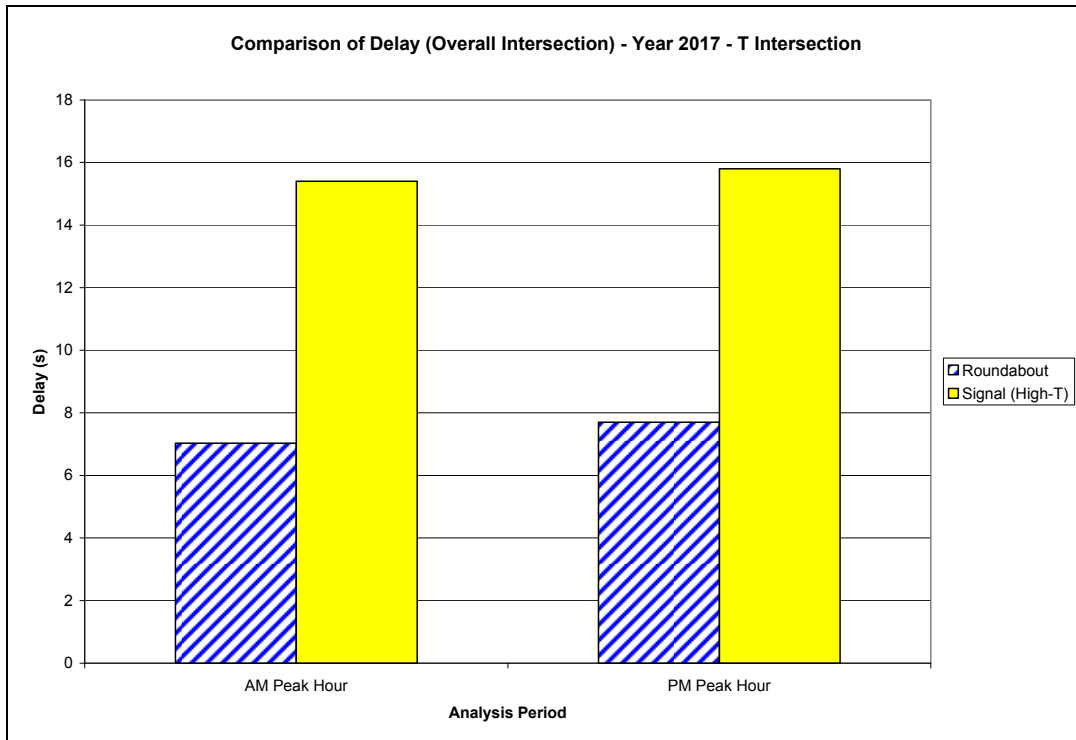


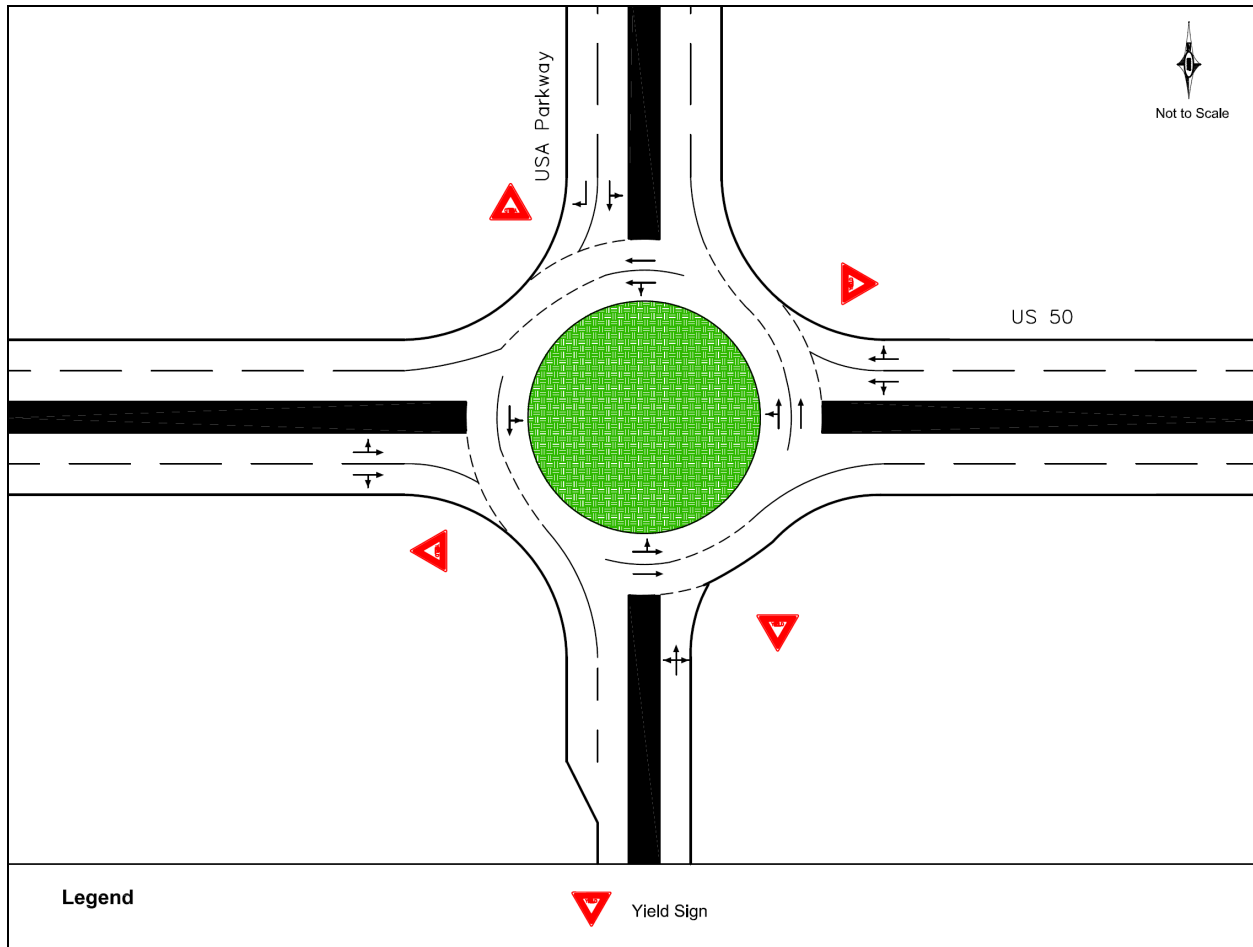
Figure 4-5 Addendum 1: Year 2017 - USA Parkway and US 50 (T-Intersection) - Analysis Results (Comparison of Overall Intersection Delay)



4.2. 4-Legged Intersection

The proposed geometry and traffic control for a roundabout at the USA Parkway and US 50 intersection (4-legged intersection) is shown in Figure 4-6 Addendum 1.

Figure 4-6 Addendum 1: Year 2017 Proposed Geometry and Control at the USA Parkway/US 50 Intersection (4-Legged Intersection)



Note: Conceptual illustration for ease of understanding only.

Analysis of the roundabout intersection was completed using HCS 2010, following HCM 2010 methodology. The results of the roundabout intersection traffic operations analysis are shown in Table 4-4 Addendum 1. Table 4-4 Addendum 1 gives the Delay, LOS and V/C for the worst lane of the roundabout as well as the overall intersection (roundabout). HCS analysis worksheets are provided in Appendix B 1 Addendum 1.

Table 4-4 Addendum 1 also gives the results corresponding to a signalized intersection at USA Parkway and US 50. The analysis of this signalized intersection option was previously documented in the “USA Parkway Traffic Operations Analysis Memorandum”.

Table 4-4 Addendum 1: Year 2017 - USA Parkway and US 50 (4-Legged Intersection) - Analysis Results

Traffic Control	Reported Performance Measures Correspond to	AM Peak Hour			PM Peak Hour		
		Control Delay (s)	HCM LOS	V/C	Control Delay (s)	HCM LOS	V/C
Roundabout	Worst lane by delay	9.4	A	0.32	10.6	B	0.42
	Overall intersection	7.8	A	0.33*	8.9	A	0.42*
Signal	Worst movement by delay	25.3	C	0.53	27.0	C	0.49
	Overall intersection	20.8	C	0.74*	21.9	C	0.80*

* HCM 2010 methodology does not provide an overall intersection V/C (HCM critical V/C). The highest lane/movement V/C for the intersection is reported as the V/C for the overall intersection.

Source: Jacobs, 2012

From Table 4-4 Addendum 1, it can be seen that, with the roundabout option, the overall intersection is anticipated to operate at LOS equal to or better than LOS D during both the AM and PM peak periods. In addition, the worst lane of the USA Parkway and US 50 intersection is anticipated to operate at LOS equal to or better than LOS E during both the AM and PM peak periods. V/C for each lane is also less than 1. It can also be seen that, the roundabout option is anticipated to result in lower delays compared to the signalized intersection option.

Figure 4-7 Addendum 1 and Figure 4-8 Addendum 1 illustrate the comparative operational performance of the roundabout option, against the signalized intersection option graphically. Figure 4-7 Addendum 1 compares the worst lane delay of the roundabout with that of the worst movement delay of the signalized intersection. Figure 4-8 Addendum 1 compares the overall intersection delay of the roundabout with that of the overall intersection delay of the signalized intersection.

Figure 4-7 Addendum 1: Year 2017 - USA Parkway and US 50 (4-Legged Intersection) - Analysis Results (Comparison of Worst Movement/Lane Delay)

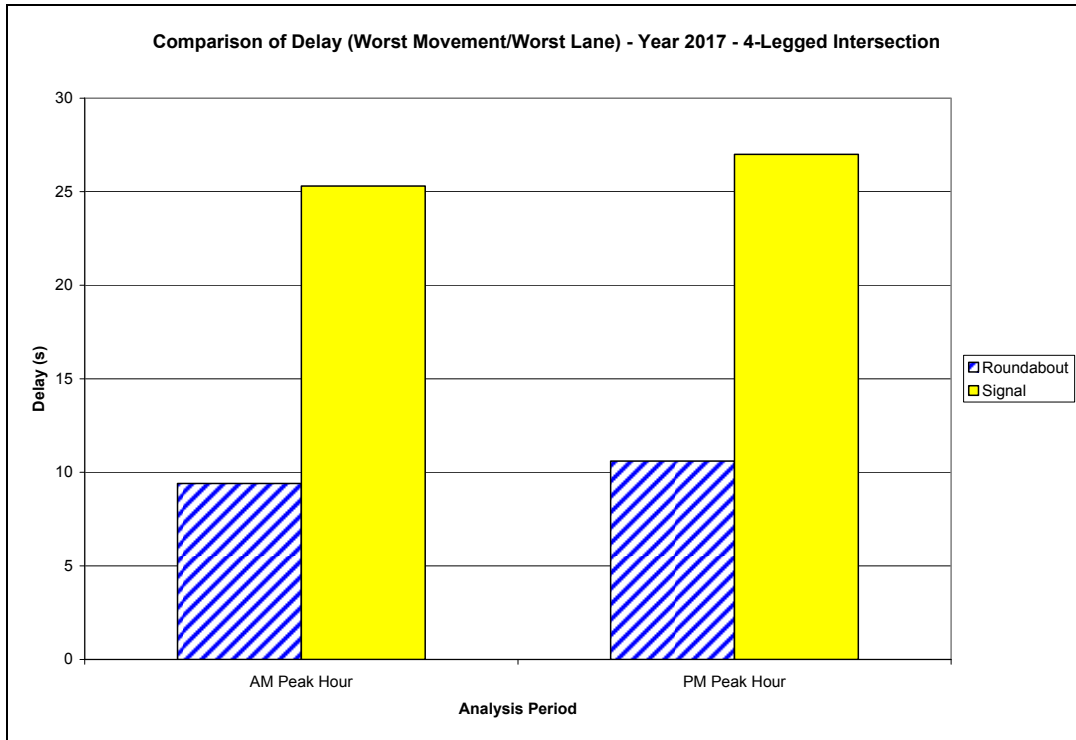
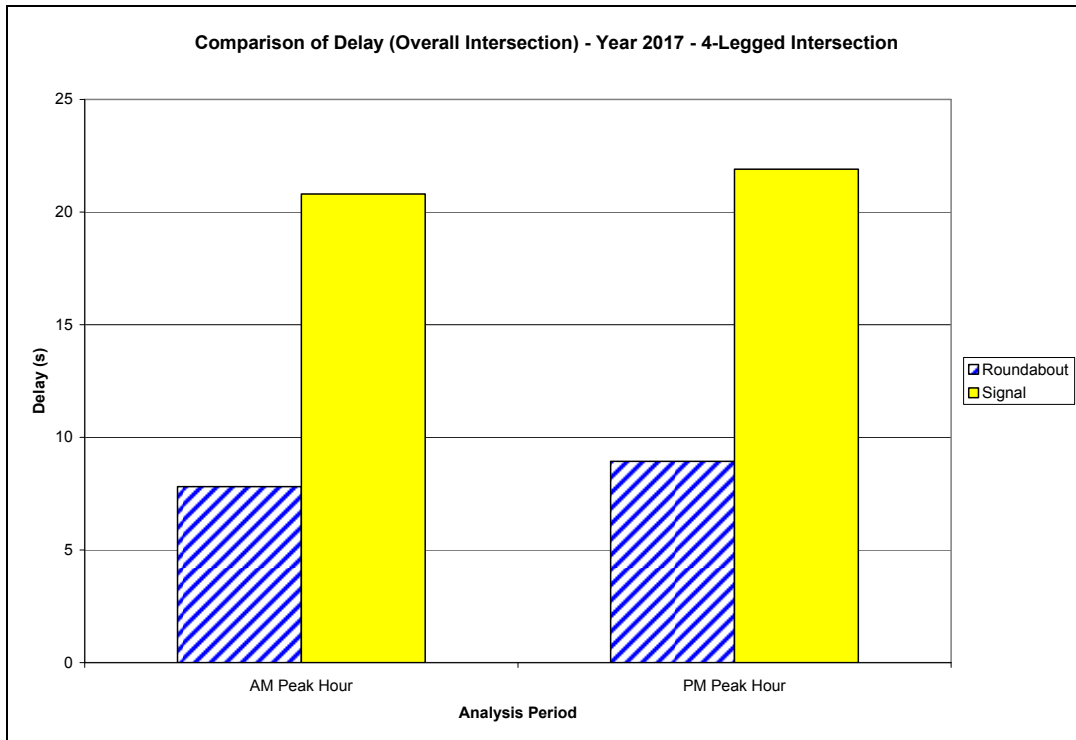


Figure 4-8 Addendum 1: Year 2017 - USA Parkway and US 50 (4-Legged Intersection) - Analysis Results (Comparison of Overall Intersection Delay)



5. DESIGN YEAR 2037 ANALYSIS

Figure 5-1 Addendum 1 shows the design year 2037 peak hour volumes and Figure 5-2 Addendum 1 shows the design year 2037 intersection turning movement volumes.

Figure 5-1 Addendum 1: Year 2037 Peak Hour Volumes (Build Alternative)

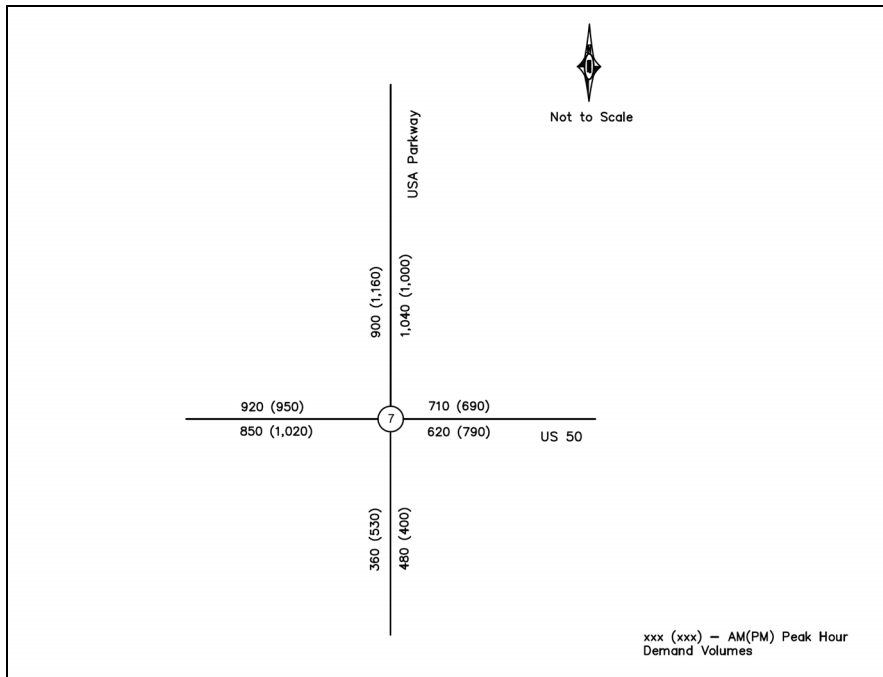
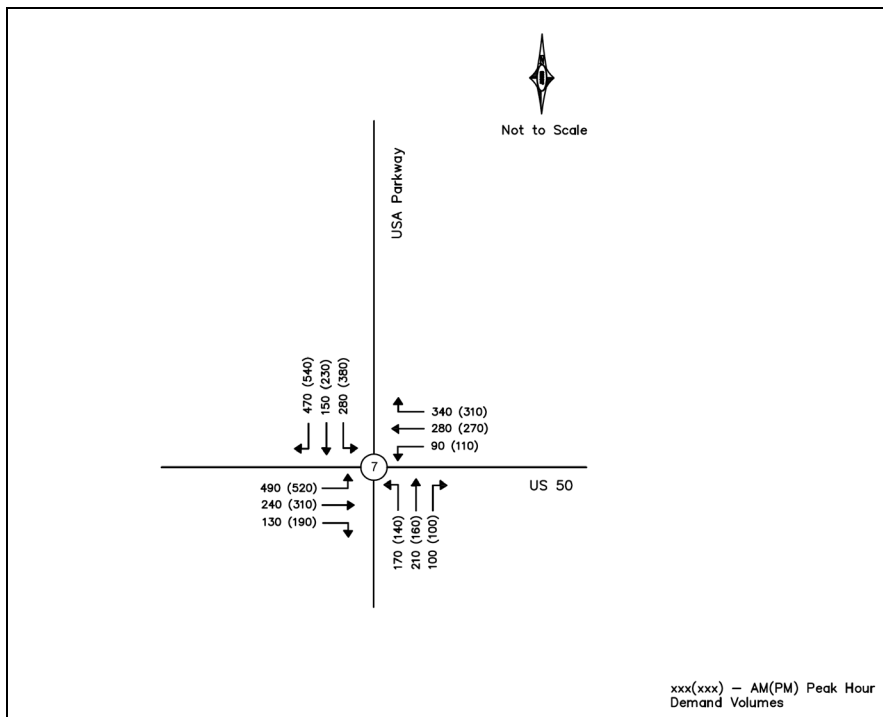


Figure 5-2 Addendum 1: Year 2037 Intersection Turning Movement Volumes (Build Alternative)

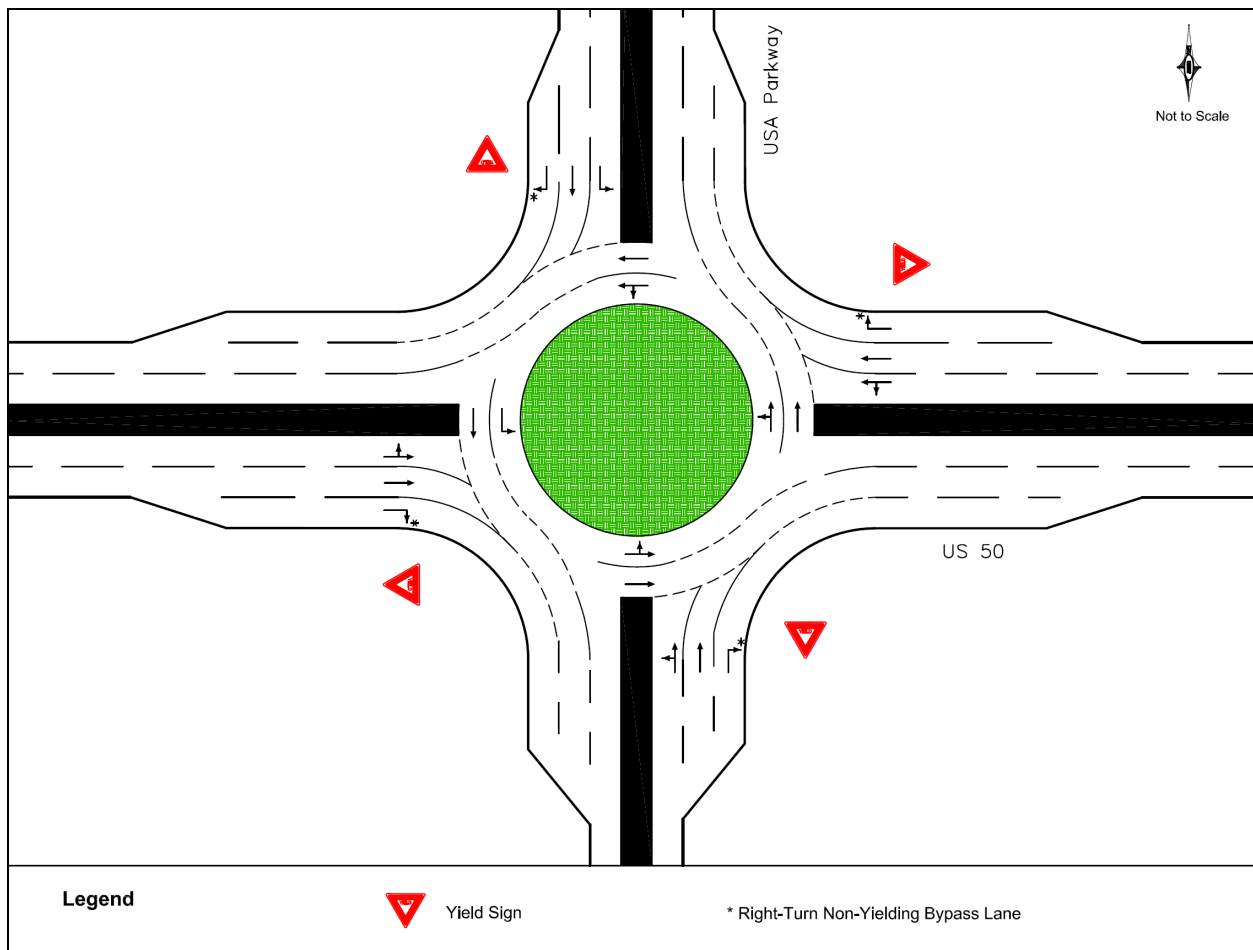


HCM LOS criteria for signalized and unsignalized intersections are shown in Table 4-1 Addendum 1. HCM LOS criteria for roundabouts are shown in Table 4-2 Addendum 1.

For the design year 2037 volumes, the performance of the opening year 2017 roundabout geometry shown in Figure 4-6 Addendum 1 was first investigated. The results of this analysis showed that both the overall intersection and the worst lane of the USA Parkway and US 50 roundabout are anticipated to operate at LOS worse than the desired LOS thresholds.

Hence, an improved roundabout geometry was proposed for the design year 2037 analysis. This proposed geometry and traffic control for a roundabout at the USA Parkway and US 50 intersection is shown in Figure 5-3 Addendum 1.

Figure 5-3 Addendum 1: Year 2037 Proposed Geometry and Control at the USA Parkway/US 50 Intersection



Note: Conceptual illustration for ease of understanding only.

Analysis of the roundabout intersection was completed using HCS 2010, following HCM 2010 methodology. The results of the roundabout intersection traffic operations analysis are shown in Table 5-1 Addendum 1. Table 5-1 Addendum 1 gives the Delay, LOS and V/C for the worst lane of the roundabout as well as the overall intersection (roundabout). HCS analysis worksheets are provided in Appendix B 2 Addendum 1.

Table 5-1 Addendum 1 also gives the results corresponding to a signalized intersection at USA Parkway and US 50. The analysis of this signalized intersection option was previously documented in the “USA Parkway Traffic Operations Analysis Memorandum”.

Table 5-1 Addendum 1: Year 2037 - USA Parkway and US 50 - Analysis Results

Traffic Control	Reported Performance Measures Correspond to	AM Peak Hour			PM Peak Hour		
		Control Delay (s)	HCM LOS	V/C	Control Delay (s)	HCM LOS	V/C
Roundabout	Worst lane by delay	30.1	D	0.83	81.4	F	1.06
	Overall intersection	11.9	B	0.83*	21.3	C	1.06*
Signal	Worst movement by delay	35.0	C	0.69	36.5	D	0.64
	Overall intersection	26.0	C	0.81*	26.5	C	0.82*

* HCM 2010 methodology does not provide an overall intersection V/C (HCM critical V/C). The highest lane/movement V/C for the intersection is reported as the V/C for the overall intersection.

Source: Jacobs, 2012

From Table 5-1 Addendum 1, it can be seen that, with the roundabout option, the overall intersection is anticipated to operate at LOS equal to or better than LOS D during both the AM and PM peak periods. Also, the worst lane of the USA Parkway and US 50 (roundabout) intersection is anticipated to operate at LOS equal to or better than LOS E during the AM peak period. However, during the PM peak period, the worst lane (Eastbound Left) is anticipated to operate at LOS worse than LOS E during the PM peak periods. The V/C for the worst lane is also greater than 1.0 for the PM peak period. This does not meet the desired level of service thresholds. It can also be seen that, the worst lane of the roundabout option is anticipated to result in significantly higher delays compared to the worst movement of the signalized intersection option during the PM peak period.

Figure 5-4 Addendum 1 and Figure 5-5 Addendum 1 illustrate the comparative operational performance of the roundabout option, against the signalized intersection option graphically. Figure 5-4 Addendum 1 compares the worst lane delay of the roundabout with that of the worst movement delay of the signalized intersection. Figure 5-5 Addendum 1 compares the overall intersection delay of the roundabout with that of the overall intersection delay of the signalized intersection.

Figure 5-4 Addendum 1: Year 2037 - USA Parkway and US 50 - Analysis Results (Comparison of Worst Movement/Lane Delay)

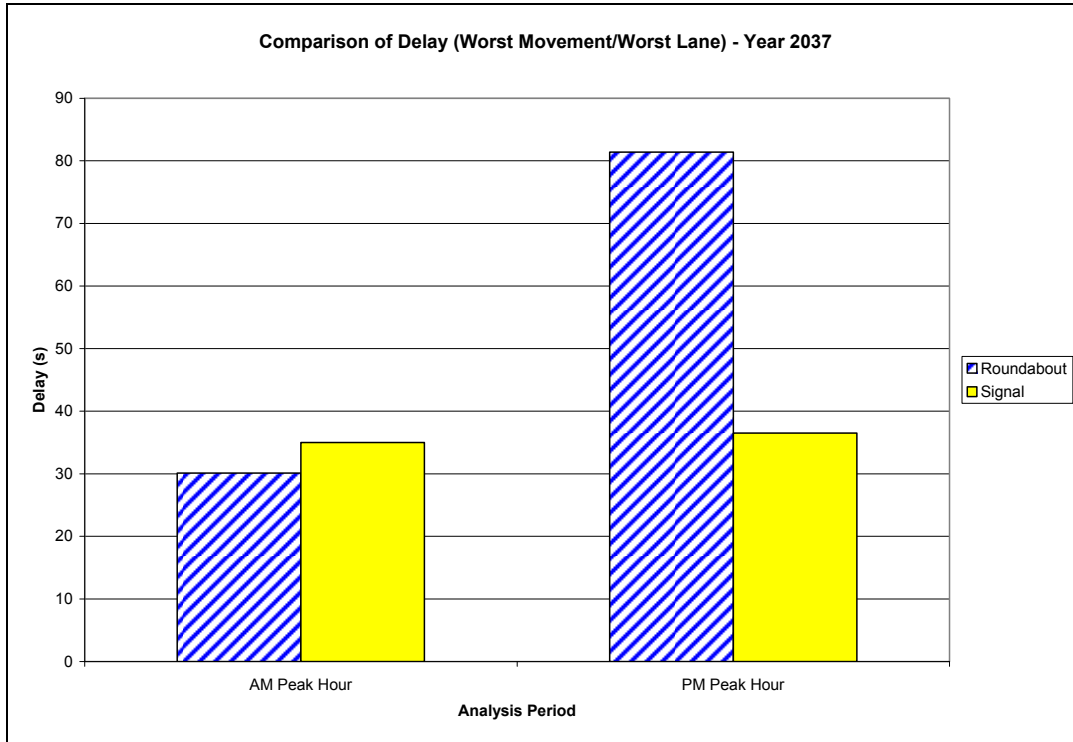
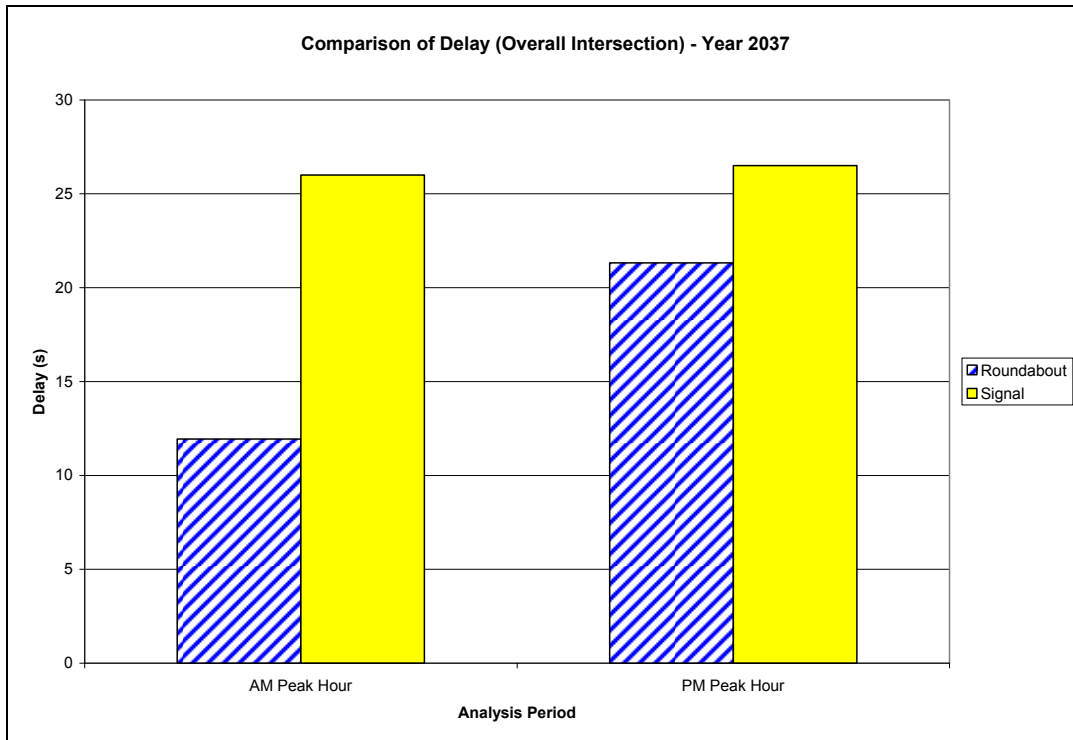


Figure 5-5 Addendum 1: Year 2037 - USA Parkway and US 50 - Analysis Results (Comparison of Overall Intersection Delay)



6. CONCLUSION

The option of a roundabout at the USA Parkway and US 50 intersection for the opening year 2017 and the design year 2037 was investigated. The operational performance of the roundabout was compared with that of other intersection geometries and traffic control options. For the opening year 2017, a roundabout is anticipated to perform operationally better than both the signalized and unsignalized traffic control options. But, by the design year 2037, the operational performance of a roundabout is anticipated to be worse than the desired LOS thresholds during the PM peak period. Additionally, the V/C ratio for the highest delay lane (Eastbound Left) of the roundabout is greater than 1.0 implying that there is inadequate capacity to serve the traffic demand.