MoveRolla
TRANSPORTATION DEVELOPMENT DISTRICT

Move Rolla TDD
University Drive Relocation
US 63 Traffic Analysis
Addendum

April 27, 2020

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This report was prepared for:

City of Rolla

Rolla Transportation Development District Board

This report was prepared by:

HNTB Corporation

1.0 Study Purpose

The purpose of this report is to present additional more detailed data to the University Drive Intersection Analysis Report, January 2020. Below is a summary of events in the order they occurred since the report was submitted to the Core Team.

1. University Drive Intersection Analysis Traffic Report, which analyzed a traffic signal and two roundabout alternatives, was completed January 31, 2020.
2. The study recommended a traffic signal as a result of concern for pedestrian safety on a US highway in a high pedestrian environment with the nearby university.
3. Move Rolla TDD Core Team approved the traffic signal recommendation.
4. Move Rolla TDD Board approved the traffic signal recommendation.
5. Through the University's Master Planning effort, the administration asked the Core Team to reconsider the roundabout alternative.
6. Move Rolla TDD Board approved an addendum scope of services to investigate additional more detailed pedestrian access and safety for both the traffic signal and roundabout alternatives.

To aid the addendum, additional resources were consulted, one of which was the Federal Highway Administration (FHWA's) National Resource Center. The National Resource Center was consulted for pedestrian safety at roundabouts. A Core Team workshop was held on April 8, 2020 to discuss the project and answer Core Team questions. Discussion items from the Core Team are provided in the Appendix and were incorporated into this report.

Figure 1: University Drive Intersection Analysis Study Area

2.0 Concepts

Concepts for a traffic signal and roundabout alternative were advanced from the University Drive Intersection Analysis Report, January 2020. Concepts were advanced based on feedback from the Core Team and FHWA. Two concepts were developed consisting of a traffic signal and a roundabout as shown in Figures 2 and 3.

The concept of the roundabout presented in the previous study was re-evaluated, putting a greater emphasis on pedestrian safety and less consideration on right-of-way takings. This resulted in a larger footprint than what was shown in the original study. After reanalyzing the traffic and refining the pedestrian movements, a hybrid configuration was determined to be the best configuration using the FHWA recommended inscribed diameter of 160'. The roundabout shown in this concept was also designed to convert to two lanes for the southbound movements if it is needed for future traffic demands. This change is depicted with the purple cross hatching in the roundabout exhibit. With the future expansion plans of the University west of US 63 it is anticipated that this intersection will see an increase in pedestrian use. With the goal of increasing pedestrian safety an offset crossing was utilized on the US 63 north and south legs of the roundabout. The crossing on the entrance is approximately 25' from the circulatory roadway and the crossings from the exit are approximately 70'. Truck aprons are also needed in this concept to accommodate the WB-67s turning movements. This design will also require a change of access to the adjacent properties. Mostly affecting what is presently a Taco Bell, Hardees and Subway.

In addition to the roundabout, a traditional signal was evaluated as a concept. The signal concept remains very similar to the one presented in the original study. When comparing the traffic signal option shown in this addendum, the traffic signal footprint is a slightly larger footprint. This was due to the modifications to the right turns from US 63 to University Drive as well as the right turn from University Drive to US 63 to accommodate the WB-67 design vehicle. Another addition are the pedestrian refuge islands. When

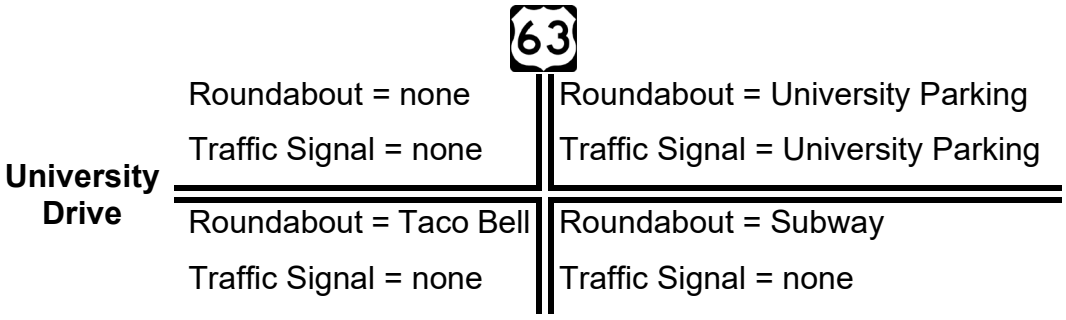
designing this intersection every attempt was made to utilize the existing US 63 roadbed when possible. This was achieved on the north leg of the intersection. On the south leg a widening of the pavement from exiting is needed on the eastside of US 63 to accommodate the dual left turns from northbound US 63 to westbound University Drive. The needed widening forced a move of the entire intersection slightly further to the north than the roundabout option. The intersection can be moved further to the south if the Missouri Department of Transportation would allow a design exception for the length of the lane transition needed to accommodate that second left turn lane. By moving the intersection further south this would limit the impact on the Hardees property. Like the roundabout option, this option will also necessitate a change of access to the Taco Bell, Hardees, and Subway properties.

ROW Impact

Right-of-Way (ROW) will be needed for the Relocated University Drive and the intersection with US 63. ROW for the relocated University Drive will be the same for either the traffic signal or roundabout. ROW for the two intersection alternatives is shown in Table 1 below. The Huddle House on the west side of US 63 would have to be purchased regardless of the alternative chosen.

Table 1

Right-of-Way Impacts/Taking by Interchange Type



Financial Impact

The cost of both the traffic signal and a roundabout at US 63 was estimated. Estimated costs include construction, engineering and right of way. Table 2 shows the costs for both alternatives. As shown, the roundabout alternative is expected to cost $2.45M more than the traffic signal cost.

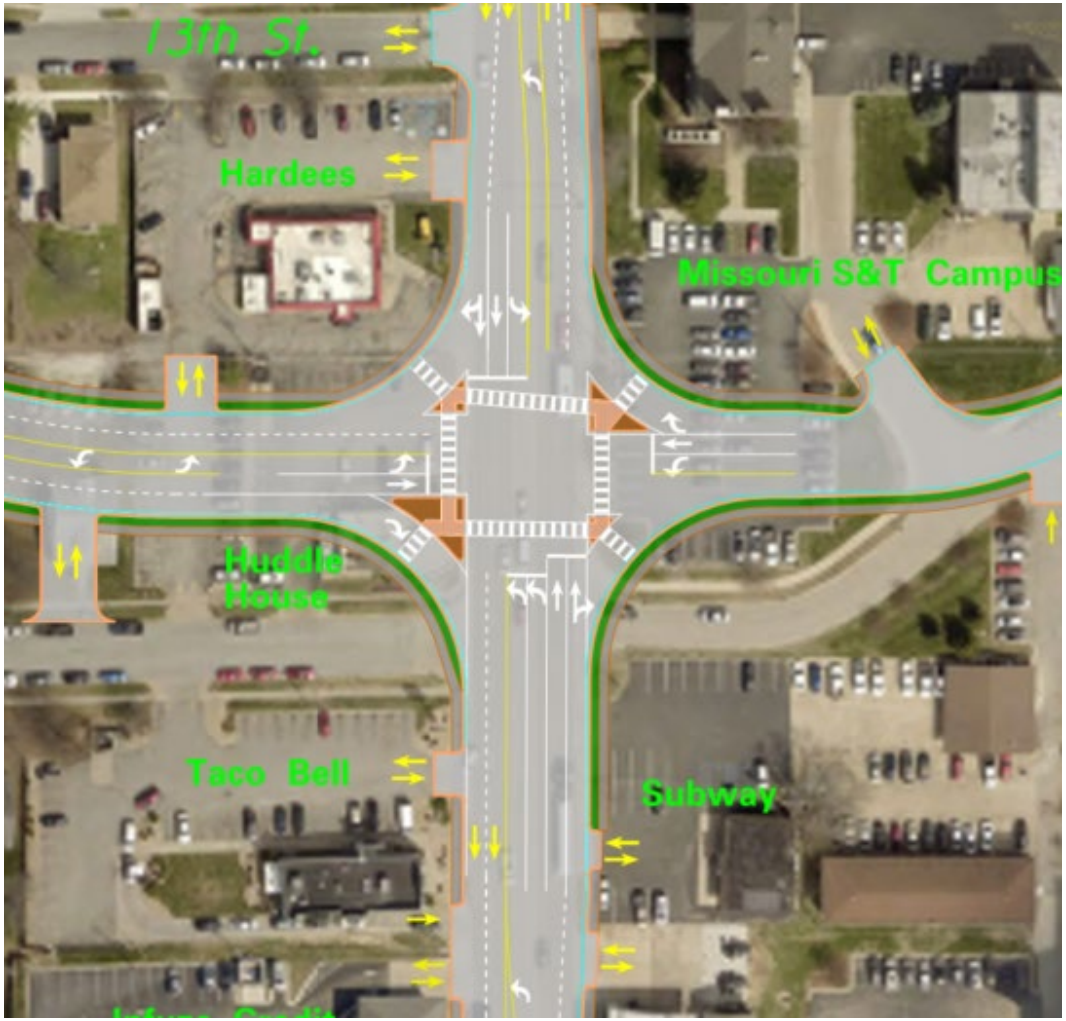
Table 2
Financial Impact

University Drive Improvements Signal Alternative		
Estimated Construction	$	3,000,000.00
A/E	$	570,000.00
Estimated Right of Way Cost	$	2,360,000.00
Total	**$**	**5,930,000.00**

University Drive Improvements Roundabout Alternative		
Estimated Construction	$	3,250,000.00
A/E	$	570,000.00
Estimated Right of Way Cost	$	4,560,000.00
Total	**$**	**8,380,000.00**

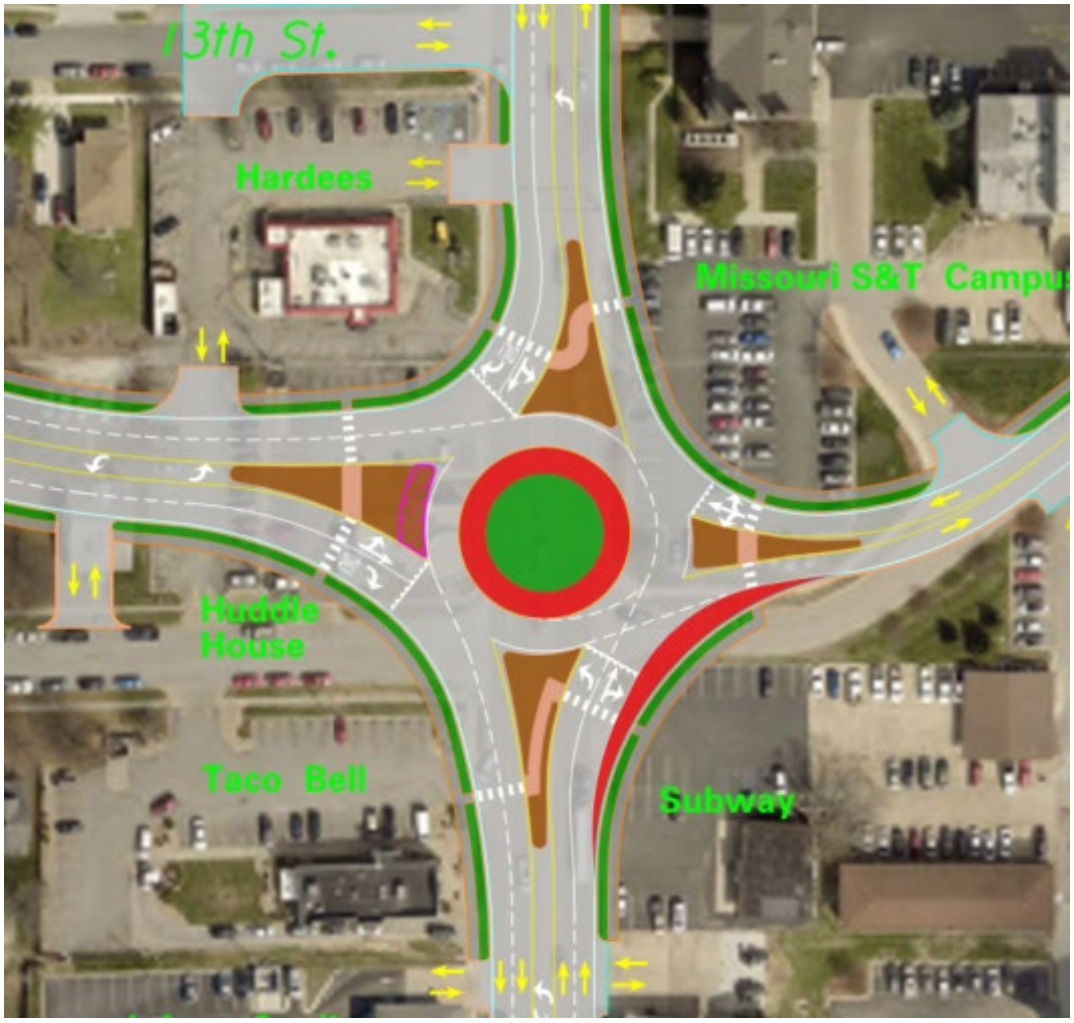
Difference	**$**	**2,450,000.00**

Figure 2
Traffic Signal Alternative



The full-size traffic signal concept is located in Appendix B

Figure 3
Roundabout Alternative



The full-size roundabout concept is located in Appendix B

3.0 Traffic Results

Traffic questions that were raised by the Core Team after the January 2020 report was submitted are addressed below in addition to updated, more detailed traffic operational results. Core Team questions were related to study intersection traffic growth, truck volumes, Level of Service and vehicle queues.

3.1 Traffic Volumes Growth

Table 3 shows the existing (2019) and design year (2040) traffic volumes, volume increase and percent increase based on the 0.6% annual growth rate assumed.

Table 3
Relocated University Drive and US 63
Traffic Volume Growth

	AM			
Approach	**2019**	**2040**	**Increase**	**Percent**
Southbound	532	603	71	13%
Westbound	31	35	4	13%
Northbound	695	789	94	14%
Eastbound	432	491	59	14%
Total	**1690**	**1918**	**228**	

	PM			
Approach	**2019**	**2040**	**Increase**	**Percent**
Southbound	684	776	92	13%
Westbound	85	96	11	13%
Northbound	881	1000	119	14%
Eastbound	370	420	50	14%
Total	**2020**	**2292**	**272**	

Assumptions
Annual Background Growth Rate equals 0.6%
Does not include new University development west of US 63 but historical growth has been stagnant / flat.

3.2 Truck Volumes

Table 4 shows peak hour truck volumes and truck percentages at the current University Drive and US 63 as well as the US 63 and Miner Circle intersections used in the analysis.

Table 4
US 63 Peak Hour Truck Volumes and Percentages

US 63 & University Dr

	AM		PM	
Approach	**2019**	**Percent**	**2019**	**Percent**
Southbound	30	6.1%	11	1.7%
Westbound	-	-	-	-
Northbound	35	6.0%	18	2.0%
Eastbound	10	2.4%	1	0.3%
Total	**75**		**30**	

US 63 & Miner Circle

	AM		PM	
Approach	**2019**	**Percent**	**2019**	**Percent**
Southbound	35	5.7%	33	3.9%
Westbound	0	0.0%	1	1.2%
Northbound	32	4.6%	21	2.4%
Eastbound	2	18.2%	0	0.0%
Total	**69**		**55**	

Assumptions
Peak hour counts
Counts taken on different days in 2019
Truck Percentage includes Single Unit & Articulated Trucks

As shown, truck percentages on US 63 range from 4.6% to 6.1%. Total intersection truck volumes are higher during the AM peak hour in the range of 69 to 75 trucks.

3.3 Level of Service

Level of Service (LOS) thresholds for signalized and unsignalized intersections is shown in Table 5. Table 6 shows the LOS for the three alternatives analyzed along with a delay comparison for each movement. LOS for signalized intersections is represented by the average of all movements. Whereas, LOS for roundabouts is defined by the worst movement.

Table 5
Intersection Level of Service Delay Thresholds

Level of Service	Signalized Intersection Delay (s)	Unsignalized Intersection Delay (s)
A	≤10	≤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, 6th Edition Exhibit 19-8 and Exhibit 20-2

Table 6
Relocated University Drive and US 63
2019 and 2040 AM and PM Intersection Level of Service and Delay (Seconds) by Intersection Type

Intersection	University Dr Signal								University Dr Roundabout (1 SB Lane)								University Dr Roundabout (2 SB Lanes)							
	2019				2040				2019				2040				2019				2040			
	AM		PM		AM		PM		AM		PM		AM		PM		AM		PM		AM		PM	
	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
University Dr & US 63	**16.2**	**B**	**25.4**	**C**	**16.8**	**B**	**27.3**	**C**	**11.2**	**B**	**14.5**	**B**	**16.0**	**C**	**57.0**	**F**	**13.6**	**B**	**12.2**	**B**	**15.6**	**C**	**15.9**	**C**
Southbound Left	37.3	D	35.0	C	40.6	D	53.3	D	4.4	A	14.2	B	6.7	A	57.0	F	3.3	A	5.3	A	3.9	A	8.4	A
Southbound Through	19.2	B	26.4	C	21.2	C	30.6	C	4.4	A	14.5	B	6.5	A	53.3	F	2.3	A	4.7	A	2.9	A	7.3	A
Southbound Right	14.8	B	24.1	C	17.5	B	28.4	C	1.9	A	4.0	A	2.0	A	21.4	C	2.4	A	4.9	A	2.9	A	7.1	A
Westbound Left	50.3	D	43.7	D	43.7	D	36.2	D	11.2	B	12.9	B	16.0	C	15.2	C	13.6	B	12.2	B	15.6	C	15.5	C
Westbound Through	47.4	D	46.4	D	37.9	D	44.5	D	7.9	A	11.1	B	7.9	A	14.4	B	7.1	A	10.5	B	7.7	A	14.9	B
Westbound Right	10.1	B	15.8	B	10.9	B	16.4	B	6.0	A	11.3	B	8.2	A	16.7	C	5.3	A	11.4	B	9.2	A	15.9	C
Northbound Left	24.5	C	39.8	D	22.2	C	51.5	D	2.6	A	4.8	A	2.9	A	7.6	A	2.6	A	4.6	A	2.7	A	7.3	A
Northbound Through	9.2	A	22.3	C	9.2	A	16.9	B	6.5	A	10.0	B	9.5	A	14.0	B	6.1	A	9.4	A	8.5	A	12.7	B
Northbound Right	7.1	A	21.1	C	7.8	A	17.0	B	5.5	A	8.5	A	8.8	A	12.1	B	5.4	A	7.9	A	7.5	A	13.5	B
Eastbound Left	32.3	C	37.2	D	32.6	C	33.0	C	4.2	A	6.2	A	6.3	A	9.3	A	3.7	A	4.9	A	5.1	A	7.4	A
Eastbound Through	32.1	C	46.2	D	32.5	C	34.3	C	4.3	A	6.0	A	6.4	A	7.7	A	3.4	A	4.6	A	4.0	A	7.1	A
Eastbound Right	7.5	A	8.5	A	8.8	A	9.8	A	2.7	A	3.9	A	3.5	A	5.3	A	2.5	A	3.3	A	2.9	A	4.2	A

Assumptions

Stop controlled delay > 50 seconds = LOS F, Pedestrians included in all analyses, Single stage crossing at Miner Circle Roundabout Approach, Two stage crossing at US 63 and University Drive Approaches, 25 ft Crosswalk Offset at All Approaches and EB and WB Roundabout Departures, 70 ft Crosswalk Offset at NB and SB Roundabout Departures

As shown in Table 3, the traffic signal alternative operates at an overall desirable LOS C; however, many of the individual movements operate at LOS D in 2019 and 2040. The University Drive Roundabout (1 SB Lane) alternative operates at LOS B in 2019. By 2040, the SB Left and Through movements operate at LOS F, which translates to an overall intersection LOS F in 2040. By comparison, the University Drive Roundabout (2 SB Lane) alternative operates at LOS B / C in 2019 and 2040, respectively. Results indicate that at some point prior to the 2040 design year, a second SB lane may be needed. When that additional lane is added, a desirable LOS and low delay are expected.

The delay of the southbound right turn in the double southbound lane roundabout alternative for the 2040 PM peak hour shows a significant decrease in delay from 21.4 seconds and LOS C for the single southbound through lane alternative to 7.1 seconds and LOS A for the double southbound through lane alternative. Since the single southbound lane alternative includes a dedicated right turn lane this may seem unexpected, however the queue from the single southbound through lane extends further than the storage length for the southbound right turn bay causing vehicles that want to make the southbound right turning movement to experience higher delays. This situation is eliminated with the double southbound lane roundabout alternative.

The relocated University eastbound right turn for the 2040 PM peak hour shows a slight delay decrease with the double southbound through lane alternative of 4.2 seconds and LOS A compared to the single southbound through lane which has 5.3 seconds and LOS A. This decrease in delay is minimal but is likely due to the increased efficiency of the double southbound through lanes which clears traffic more effectively in the roundabout and creates more vehicle gaps for the relocated University eastbound right turning vehicles to enter the roundabout and turn right.

Relocated University Drive future 2040 traffic demand was analyzed with the purpose of evaluating the current planned University Drive 5-lane typical section compared to a 3-lane typical section.

- The existing 2019 University Drive 2-way ADT is 8,949[1]
- 2040 AM peak hour 2-way traffic volumes west of US 63 are 784[2]
- 2040 PM peak hour 2-way traffic volumes west of US 63 are 898[2]
- 2040 ADT on a relocated University Drive is 10,200[3]
- MoDOT's engineering policy guide (EPG) shows that the capacity of a 3-lane roadway is 17,500 vehicles per day.
- Therefore, the 2040 University Drive volume/capacity is 0.58.
- For reference the existing 2019 Kingshighway 2-way ADT is 14,867[1].

Notes

1 MoDOT Traffic Website – 2019 count

2 Traffic counts collected by the City in 2019

3 Used same 0.6% annual background growth rate as study

The relocated University Drive is planned to be a limited access facility with only one intersection between the I-44 Interchange and US 63. The relocated University Drive could be modified to a 3-lane roadway with excess capacity in the design year. However, reducing University Drive to a 3-lane section between US 63 and I-44 there is still going to be a 5-lane section at the University roundabout or traffic signal to account for the needed approach and departure lanes and a 5-lane section at the I-44 Interchange to match the existing configuration east of the interchange. An unknown assumption in this analysis is the trip generation of planned University property between the relocated University Drive and the existing University Drive west of US 63 and its impact on design year traffic demand.

Traffic Calming

The *MoveRolla TDD Concept Study, 2018* identified a vision and a set of goals that the Transportation Development District Board wanted to accomplish,
The TDD vision was to:

> *Develop a transportation system that meets the needs of all people and modes and promotes a safe, healthy community and economic opportunities for the next 20 years.*

The TDD goals were to:

- Develop a safe and convenient transportation environment,
- Promote alternative mobility choices,
- Develop a transportation system that promotes economic opportunities, and
- Create a sense of place.

Within this vision and goals, was one objective to convert US 63 from a state highway to a local main street - Bishop Avenue. Many core team meetings talked about making Bishop Avenue a Complete Street that balanced bicycle and pedestrian mobility with the local traffic and relocated through traffic around the City as much as possible. In addition, slowing traffic to a speed more consistent with the high number of pedestrians of the University was considered desirable.

Converting US 63 to a more locally controlled complete street is a large undertaking that is expected to be accomplished over time. A complete street can be accomplished with either a traffic signal or roundabout alternative at University Drive and Miner Circle.

3.4 Vehicle Queues

Vehicle queues were analyzed using the same microsimulation model used to analyze motorist delay and LOS. Vehicle queue results are shown in Figures 4 – 6. First, approach vehicle queues were analyzed for the AM and PM peak hours. A vehicle queue comparison of the three alternatives is shown side by side for all approaches to the relocated University Drive and US 63 as well as the SB approach to 10th Street and US 63. Secondly, departure queues from the relocated University Drive and US 63 are provided for the PM peak hour as a result of a rectangular rapid flashing beacon for pedestrian use to cross US 63, relocated University Drive and Miner Circle. AM departure queues are not shown because they were analyzed and found to be zero in length.

Rectangular Rapid Flashing Beacon (RRFB) pedestrian crossing

Figure 4
AM Peak Hour Approach Queues

University Dr. & US 63 Queues
Signal 2019[1]
Signal 2040[1]

Roundabout (1 SB Lane) 2019[1]
Roundabout (1 SB Lane) 2040[1]

Roundabout (2 SB Lane) 2019[1]
Roundabout (2 SB Lane) 2040[1]

10th Street & US 63 Queue[2]
Signal 2019[1]
Signal 2040[1]

Roundabout (1 SB Lane) 2019[1]
Roundabout (1 SB Lane) 2040[1]

Roundabout (2 SB Lane) 2019[1]
Roundabout (2 SB Lane) 2040[1]

[1] 95th Percentile Queue
[2] Results based on intersection control type at University

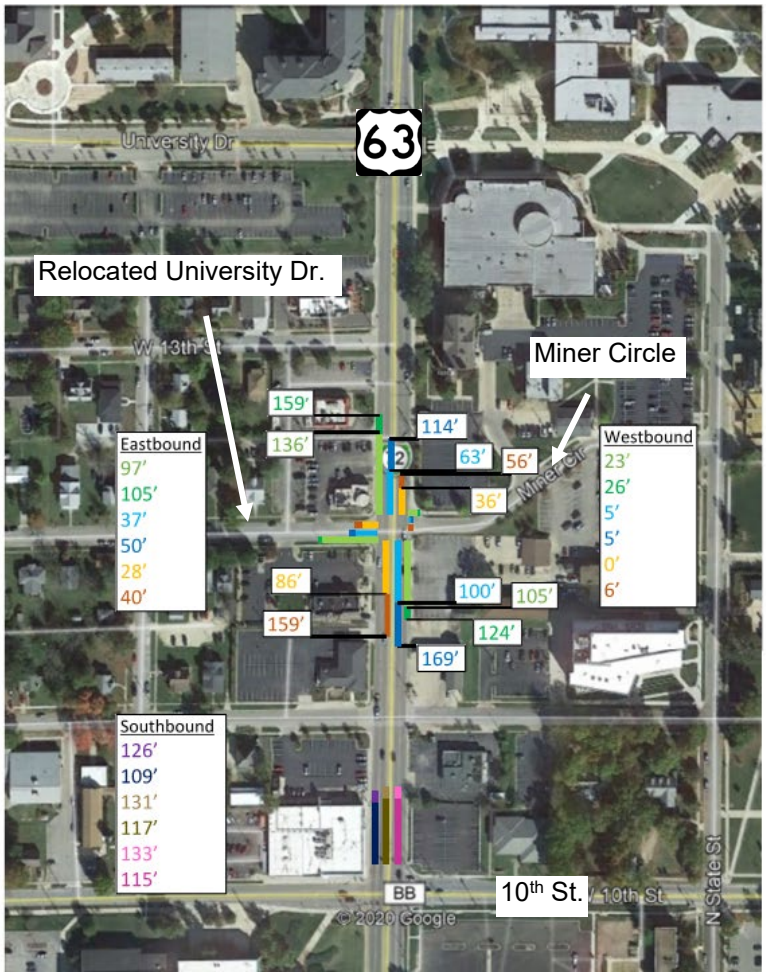


Figure 5
PM Peak Hour Approach Queues

University Dr. & US 63 Queues
Signal 2019[1]
Signal 2040[1]

Roundabout (1 SB Lane) 2019[1]
Roundabout (1 SB Lane) 2040[1]

Roundabout (2 SB Lane) 2019[1]
Roundabout (2 SB Lane) 2040[1]

10th Street & US 63 Queue[2]
Signal 2019[1]
Signal 2040[1]

Roundabout (1 SB Lane) 2019[1]
Roundabout (1 SB Lane) 2040[1]

Roundabout (2 SB Lane) 2019[1]
Roundabout (2 SB Lane) 2040[1]

[1] 95th Percentile Queue
[2] Results based on intersection control type at University

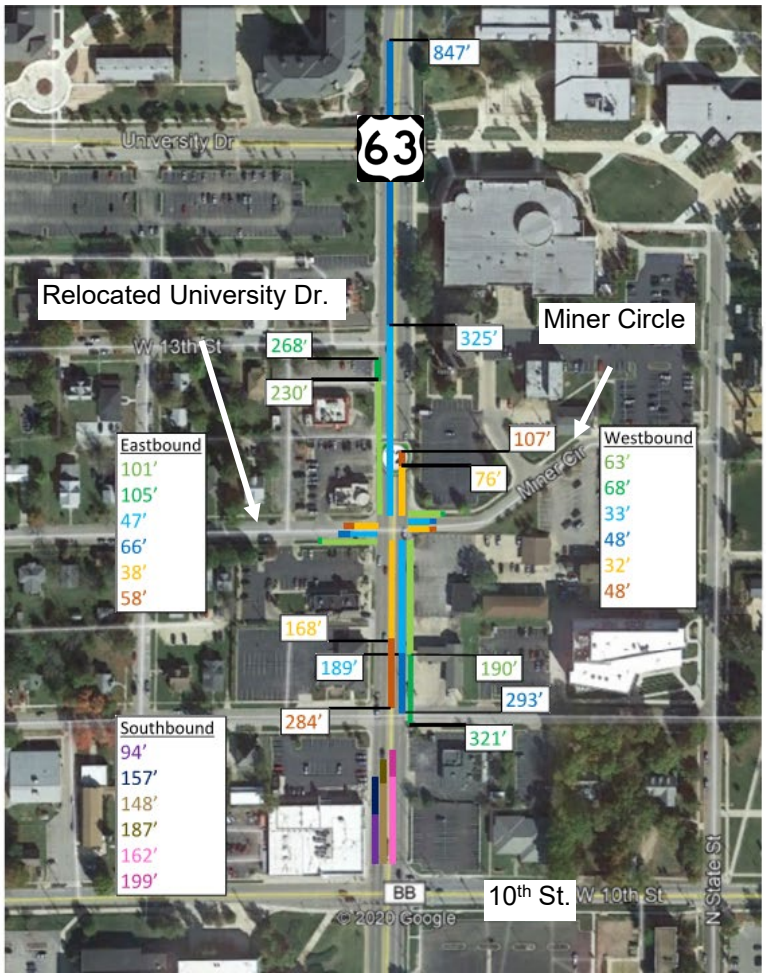


Figure 6
PM Peak Hour Departure Queues

University Dr. & US 63 Queues

Roundabout (1 SB Lane) 2019[1]
Roundabout (1 SB Lane) 2040[1]

Roundabout (2 SB Lane) 2019[1]
Roundabout (2 SB Lane) 2040[1]

The AM 95th Percentile Queues are less than 10 ft in all directions in 2019 and 2040 and therefore not displayed

The map on the right shows the required crosswalk offset to allow adequate storage for vehicles exiting the roundabout for a single stage crossing so as not to block the vehicles in the roundabout.

[1] 95th Percentile Queue

In summary, the 2019 and 2040 AM peak hour approach queues (Figure 4) indicate minimal vehicle queues with no queue length greater than 169 feet during the peak hour. In addition, the longest SB approach vehicle queue to 10th Street is 133 feet.

In the 2019 and 2040 PM peak hour approach queues (Figure 5) indicate much longer vehicle queues compared to the AM peak hour. The longest vehicle queues are observed on US 63. For the 1-lane SB roundabout, SB approach vehicle queues extend to 325 feet in 2019 and extend to 847 feet by 2040. When a 2-lane SB roundabout is constructed, 2040 vehicle queues see a significant benefit, dropping to 107 feet. In the NB direction, vehicle queues are not as long as in the SB direction, with all three alternatives performing similarly around 300 feet, which extends to approximately 11th Street.

Finally, 2019 and 2040 PM peak hour departure queues (Figure 6) were also developed from the microsimulation model. The results indicate that departure queues are highest on the NB departure side of the relocated University Drive intersection for the two roundabout alternatives. As shown, initial 2019 departure queues are as low as 37 feet but by 2040 would increase to 170 feet if a second SB lane were not added. Once the additional SB lane is added, the NB departure queues extends to 149 feet by 2040.

4.0 Recommendation

A Core Team meeting was held on April 23, 2020. The Core Team's recommendation to the TDD Board is for a traffic signal at the intersection of the relocated University Drive and US 63. This decision was made for the following reasons.

1. The traffic signal cost $2.45M less than the roundabout.
2. The traffic signal had two fewer total property takings. The roundabout would have to acquire Taco Bell and Subway.
3. The traffic signal will serve the high pedestrian volume better than the roundabout.

Appendix A
FHWA Feedback

The FHWA National Resource Center was consulted in the area of pedestrian safety at roundabouts. A Core Team workshop was held on April 8, 2020 to discuss the project and answer Core Team questions. Discussion items from the Core Team are provided below.

Roundabout Design

- 150' - 160' diameter is typical size for a hybrid roundabout. 160’ is best place to start.
- FHWA encourages right sizing to reduce speeds, use less ROW, and create better connections.
- FHWA thinks the Rolla 2-lane roundabout is borderline in 2040 when taking a broad look at the data.
- FHWA has seen communities that think if you don't need 2-lanes for 10 years then don't build 2-lanes at first.
- Many states are looking at a staged approach and re-evaluating in 10-years.
- Trucks can straddle the lane markings. This can affect capacity, but not a lot.
- Fewer lanes = less risk for cars and pedestrians.
- FHWA design for pedestrian crossing guidance for the approach is one car / 25ft. and departure is 30’ to 70’
- Offset pedestrian two-stage crossing is acceptable.
- 160' diameter roundabout is within the guidance for roundabout diameters for trucks. Based on Rolla truck volumes the City should not expect significant truck impact
- Designing a single southbound lane initially with the intention to convert to double lane in the future is acceptable
- Volume is very borderline in looking at a single vs double lane, even in 2040. Always go with a single lane first if at all possible, multiple factors must be considered for double lane.

Pedestrian Crossing

- College kids don't cross at crosswalks; they will need to be channelized using landscaping, walls, etc.
- FHWA has seen locations with higher pedestrian volumes and traffic than Rolla that work well.
- MoDOT has used raised crosswalk approaching a traffic signal but usually on a turning lane.
- Latest research rooted in accessibility has shown two stage crossing reduces incidents.
- Research has shown vehicles yield more on the entrance as opposed to the exit of the roundabout. This has led to the placement of the offset at the exit further from the circulatory road than the entrance.
- Useful roundabout resources are NCHRP 672 and NCHRP 834.
- Draft PROWAG (Proposed Guidelines for Accessible Rights of Way, US Access Board) has not been adopted as law but is considered best practice.
- FHWA considers PROWAG the standard.
- Rectangular Rapid Flashing Beacon (RRFB) and raised crosswalk are popular with multilane roundabouts.
- RRFB success has been demonstrated within Rolla.
- Agencies are generally adopting PROWAG recommendations.
- Pedestrian hybrid beacon may be needed for higher speed roads above 35 mph. Posted speed on US 63 is 35 mph.
- Pedestrian Crossings - The RRFB's and Pedestrian Hybrid Beacons are most common at roundabouts and becoming more widely accepted. RRFB's in Rolla is good for familiarity. There is success with RRFB & Beacons for multilane ped crossings.

Example

FHWA provided two examples with similar circumstances in Olympia, WA and at NC State University.

- **Olympia, WA -**
  - High pedestrian volumes
  - Rectangular rapid flashing beacon
  - Government complex including pedestrians
  - FHWA suggests a supplemental push button in splinter island to facilitate a two-stage crossing.
- **NC State University Campus**
  - Has been retrofitted a few times from a full 2-lane to a hybrid
  - Has also seen Roundabouts designed at a single lane to be converted to 2-lane, joint placement is important.
  - FHWA does not recommend striping out for a single lane today and multilane in the future.
- University of Michigan campus has lots of roundabouts also.

Appendix B

Traffic Signal Concept
Roundabout Concept

University Dr.

US 63

Poole Ave.

Spring Ave.

State St.

Dairy Queen Grill & Chill

13th St.

Hardees

Missouri S&T Campus

Miner Cir.

Huddle House

12th St.

Taco Bell

Subway

Infuze Credit Union

Midwest Petroleum

11th St.

Kyoto Restaurant

UNIVERSITY DRIVE REALIGNMENT
SIGNALIZED INTERSECTION

SCALE

0 60 120 180 240 250

LEGEND

- Proposed Pavement
- Proposed Sidewalk
- Proposed Parkway
- Proposed Raised Median
- Proposed Depressed Median

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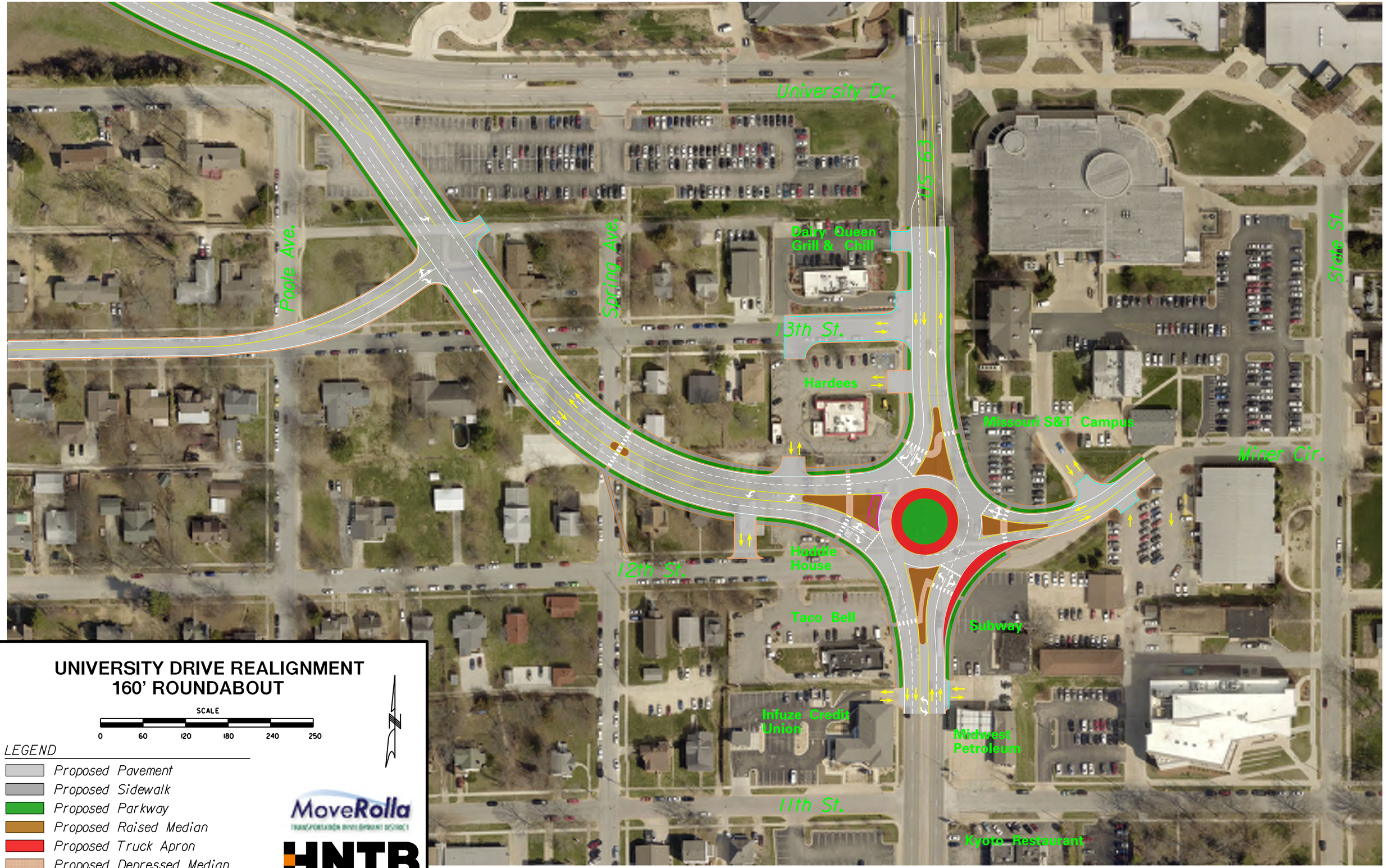

UNIVERSITY DRIVE REALIGNMENT
160' ROUNDABOUT

SCALE

0 60 120 180 240 250

LEGEND

- Proposed Pavement
- Proposed Sidewalk
- Proposed Parkway
- Proposed Raised Median
- Proposed Truck Apron
- Proposed Depressed Median

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