Ourston Roundabout Engineering

August 30, 2011

Los Alamos County
Engineering Division
1925 Trinity Drive, Suite B
Los Alamos, NM 87544

Attention: Mr. Kyle Zimmerman, PE, CFM, PTOE
County Engineer

Dear Kyle:

Re: NM 502 Transportation Corridor Study and Plan
Peer Review
Los Alamos, New Mexico
Our Project Number: ORE-11969

We have completed our review of the capacity performance of the proposed roundabouts to be located along the NM 502 corridor in Los Alamos, New Mexico. Our services included a two stage approach where we: 1) reviewed the capacity analysis presented in the *NM 502 Transportation Corridor Study and Plan*, August 16, 2011, MIG, Inc. and 2) conducted an analysis of the capacity of select roundabouts on this corridor using an additional roundabout capacity analysis method (ARCADY).

1) Review of *NM 502 Transportation Corridor Study and Plan*

We have reviewed the capacity analysis and performance prediction results in the subject report focusing on the methodology of the roundabout analysis. Our comments follow arranged by report section:

Operational Characteristics of Alternatives Overview

a) We agree that NCHRP Report 572 can be used for a planning level roundabout analysis. When the results of this method show roundabout operation being close to capacity it is recommended that deterministic software be used to verify the results. It is important, even at a conceptual stage, that appropriate roundabout parameters (inscribed circle, lane configuration) are selected to determine a realistic roundabout configuration for comparison to alternatives.
b) SIDRA is widely used in the United States, but disagree that 80% of roundabouts are analyzed using this software. Empirical software such as RODEL or ARCADY are prevalent in analysis of U.S. roundabouts. Rather than relying on one software package we will present a summary of the output of ARCADY for consideration with respect to the reported SIDRA and HCM results.

Evaluations of Improvements Concepts

a) The intersection performance tables show several proposed roundabout entries with V/C ratios exceeding 0.85, some exceeding 1.0. This means that there is more volume than capacity which will result in very poor

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operational performance during the peak hour. Consideration of the performance of each approach is much more meaningful than the overall intersection performance. When V/C ratios exceed 0.85, queuing and delay estimations are highly variable and unpredictable. It is not recommended to design for V/C ratios exceeding 0.85.

b) Some of the results of the roundabout analyses between Alternatives A1, A2, and A3 are not equal. SIDRA software and HCM analyze each intersection independently and do not consider a string of intersections. Therefore, with equal software inputs, the output should be equal as well.

Comparison of Preliminary Alternatives

a) "Vehicular queuing will be improved in all scenarios with Alternatives A1 and A2 reducing queue lengths by eliminating stop controls…" – while this may be true during the off peak periods, the intersection performance summary tables do not support this statement for the peak periods.

Corridor Travel Time (Synchro Model Comparison)

a) Synchro is not a suitable tool to analyze roundabout capacity. The results of the Synchro corridor travel time comparison are misleading because they do not correlate with the HCM analysis. For example, adding the total delay at each roundabout predicted by HCM for Alternative A1 (EB future volumes) results in a delay value of 21.5 minutes in the PM peak hour for the intersections alone. The Synchro summary states a value of 8.69 minutes for the total corridor travel time. We understand that two models were used and that an exact correlation is not expected, but the high variation between the values is cause for further consideration.

b) "option with all roundabouts is likely to provide the faster travel times due to the fact that the roundabouts contribute no operational delay." - this statement is not supported by the operational results presented in the "Evaluations of Improvement Concepts" section.

Preferred Alternative: Alternative A3

a) Adding right hand turn lanes in the future condition is not a realistic way to add capacity. The major movements are through movements which would not benefit from removing the relatively minor volume of right-turning traffic.

Detailed Analysis of Alternative A3

a) Environmental Factor – consideration should be made for a higher value for the environmental factor. Lower capacity conditions could be a result of factors such as compact roundabout design, high pedestrian volumes, and heavy vehicle activity. The site context of these locations suggests that a higher factor value is realistic. Urban locations with slow speed entries and pedestrian crossings can be expected to result in lower capacities than a similar high-speed rural location. In a new location on a highly utilized roadway it is suggested that a slightly pessimistic capacity prediction is utilized.

b) LOS Analysis (Table 4.2) – the values in this table do not correlate with the results in the previous sections. Consideration of the performance of each approach is much more meaningful than the overall intersection

performance. Only considering the overall intersection performance may conceal the failure of a single approach.

c) Tables 4.3 through 4.11 – the operational values in these tables do not match the results of the previous sections. We understand that two models were used and that an exact correlation is not expected, but the high variation between the values is cause for further consideration.

d) Queuing – queues of 1,302 feet are excessive and indicative of a roundabout operating at capacity. When V/C ratios exceed 0.85, queuing and delay predictions are highly variable and unpredictable.

2) Additional Capacity Analysis

ARCADY Methodology

Capacity analyses were performed using ARCADY 7 (Version 7.1.0.228, February, 2011) roundabout design and analysis software. ARCADY is identical to RODEL at its core, ARCADY uses the long established TRL/Kimber capacity relationships, which take into account key roundabout geometries such as entry width, flare length and inscribed circle diameter. This empirical framework intrinsically links roundabout geometry to driver behavior and in turn to predicted capacities, queues and delays. ARCADY has been successfully used to design and re-design thousands of roundabouts throughout the world including the U.S. ARCADY calculates and reports the slope and intercept of the capacity equation for each roundabout entry allowing for calibration to nationally established capacity studies like NCHRP Report 572. For comparison purposes, the capacity analyses performed for this project include standard un-calibrated capacity results, as well calibrated capacity results. In general, there is still debate over what the capacity of roundabouts in North American is, or will be, by the time roundabout designs reach their "design year". There has been a belief, that as North American drivers become more proficient at driving roundabouts, in conjunction with better roundabout design practices being implemented, roundabout capacity will increase to the range predicted by RODEL/ARCADY. Recent data collected in Bend, Oregon, a city with over twenty-five roundabouts, suggests this is already occurring, as their roundabouts are performing well above the NCHRP-572 predictions. The "Un-calibrated" reference in this report refers to default capacity predictions of RODEL/ARCADY. To provide a more conservative capacity prediction allowing for the possibility that these roundabouts do not reach the capacity of the software default, a 10% capacity reduction has been applied to the Y-intercept (capacity reduction) for comparison purposes. The analysis with the Y-intercept adjustment is referenced as "Calibrated' in this report. The calibrated capacity predictions can be used to identify trends and weakness of each entry as traffic volumes increase over time, assuring confidence in a robust design.

Capacity Analysis Results

Our capacity analysis included the four intersections that you directed us to analyze: Oppenheimer Drive, 15th Street, 4th St. / Central Ave., and Tewa Loop. The intersections were analyzed using the 2010 and 2030 forecast volumes provided by MIG, Inc. as shown in Appendix D of the *NM 502 Transportation Corridor Study and Plan*, August 16, 2011. The ARCADY LOS results are shown in Table 1.

Table 1 – ARCADY LOS Results

		2010 AM		2010 PM		2030 AM		2030 PM	
		ARCADY	ARCADY Calibrated	ARCADY	ARCADY Calibrated	ARCADY	ARCADY Calibrated	ARCADY	ARCADY Calibrated
Oppenheimer Dr.	SB Oppenheimer	A	A	A	A	A	A	A	A
	EB NM 502	A	A	D	F	A	A	F	F
	NB Oppenheimer	A	A	A	A	A	A	A	A
	WB NM 502	A	A	A	A	B	C	A	A
15th Street	SB 15th	A	A	A	A	A	A	A	A
	EB NM 502	A	A	E	F	A	A	F	F
	NB 15th	A	A	A	A	A	A	A	A
	WB NM 502	A	A	A	A	A	A	A	A
4th/Central	SB 4th/Central	A	A	A	A	A	A	A	A
	EB NM 502	A	A	F	F	A	A	F	F
	WB NM 502	F	F	A	A	F	F	A	A
Tewa Loop	SB Tewa Loop	A	A	A	A	A	A	A	A
	EB NM 502	A	A	F	F	A	A	F	F
	NB Tewa Loop	A	A	A	A	A	A	A	A
	WB NM 502	E	F	A	A	F	F	A	A

The complete results of the ARCADY analyses for the four intersections that were analyzed are summarized in the attached Tables 2-5.

Software Results Comparison

A comparison of the ARCADY (uncalibrated and calibrated) and HCM capacity limits are shown on the attached Figure 1. This figure also shows the 2030 volume data points for the EB entry of each proposed roundabout to illustrate the volume projection with respect to capacity prediction limits for a typical NM 502 roundabout entry.

Findings and Recommendation

Our analysis shows that single lane roundabouts will not adequately handle the existing or future traffic volumes for select approaches. The capacity predictions for these critical entries are generally below the traffic volumes, resulting in V/C ratios exceeding 0.85. It is not recommended that roundabouts be designed with V/C ratios exceeding 0.85 as queuing and delay estimations are highly variable and unpredictable.

The use of roundabouts to address the purpose and need of this corridor study is applicable. Roundabouts can provide a safety improvement for all users, improve the modes of travel, and support social and economic vitality. It is recommended that roundabouts with an appropriate lane configuration to handle the projected traffic volumes be considered. Even though right-of-way constraints are compact, careful design of multi-lane roundabouts which only require minimal and strategic right-of-way takes would make this alternative viable. An evaluation of a multi-lane roundabout alternative against the conventional intersection alternatives may prove to result in the same evaluation consensus where roundabouts are the preferred alternative.

Yours truly,

OURSTON ROUDABOUT ENGINEERING

Troy Pankratz, P.E.
Project Manager

TP/

Table 2 – Oppenheimer Drive ARCADY Summary

		NM 502 / Oppenheimer Drive							
		ARCADY Un-Calibrated				ARCADY Calibrated			
		95% Queue (ft)	Delay (Sec)	V/C	LOS	95% Queue (ft)	Delay (Sec)	V/C	LOS
2010 AM	SB Oppenheimer	2	4.9	0.07	A	2	5.5	0.08	A
	EB NM 502	17	5.3	0.46	A	20	6.5	0.52	A
	NB Oppenheimer	2	4.3	0.1	A	2	4.8	0.11	A
	WB NM 502	28	7.1	0.6	A	37	9.5	0.66	A
2010 PM	SB Oppenheimer	2	4.2	0.09	A	2	4.7	0.1	A
	EB NM 502	202	34.8	0.93	D	679	104.3	1.03	F
	NB Oppenheimer	3	7.7	0.12	A	3	8.1	0.13	A
	WB NM 502	18	5.8	0.49	A	23	7.1	0.55	A
2030 AM	SB Oppenheimer	2	6.0	0.11	A	2	6.8	0.12	A
	EB NM 502	25	6.6	0.57	A	33	8.6	0.63	A
	NB Oppenheimer	3	4.9	0.14	A	3	5.5	0.15	A
	WB NM 502	52	10.8	0.73	B	81	17.1	0.81	C
2030 PM	SB Oppenheimer	3	4.8	0.12	A	3	5.4	0.13	A
	EB NM 502	1943	264.7	1.14	F	3514	574.2	1.27	F
	NB Oppenheimer	4	9.3	0.17	A	4	8.5	0.16	A
	WB NM 502	29	7.4	0.6	A	38	9.8	0.67	A

Table 3– 15th Street ARCADY Summary

		NM 502 / 15th Street							
		ARCADY Un-Calibrated				ARCADY Calibrated			
		95% Queue (ft)	Delay (Sec)	V/C	LOS	95% Queue (ft)	Delay (Sec)	V/C	LOS
2010 AM	SB 15th	4	4.7	0.18	A	5	5.3	0.2	A
	EB NM 502	15	5.1	0.44	A	18	6.2	0.49	A
	NB 15th	0	0.0	0	A	0	0.0	0	A
	WB NM 502	18	5.7	0.49	A	23	7.1	0.55	A
2010 PM	SB 15th	7	5.0	0.27	A	8	5.8	0.3	A
	EB NM 502	290	49.9	0.96	E	957	144.2	1.07	F
	NB 15th	1	8.3	0.03	A	1	8.3	0.03	A
	WB NM 502	17	5.7	0.47	A	20	6.9	0.52	A
2030 AM	SB 15th	6	5.6	0.24	A	7	6.5	0.27	A
	EB NM 502	22	6.2	0.54	A	28	8.0	0.6	A
	NB 15th	0	0.0	0	A	0	0.0	0	A
	WB NM 502	29	7.3	0.6	A	39	9.8	0.67	A
2030 PM	SB 15th	11	6.2	0.36	A	13	7.4	0.4	A
	EB NM 502	2469	374.1	1.2	F	4240	711.2	1.33	F
	NB 15th	1	9.5	0.03	A	1	8.7	0.03	A
	WB NM 502	25	7.1	0.57	A	32	9.0	0.63	A

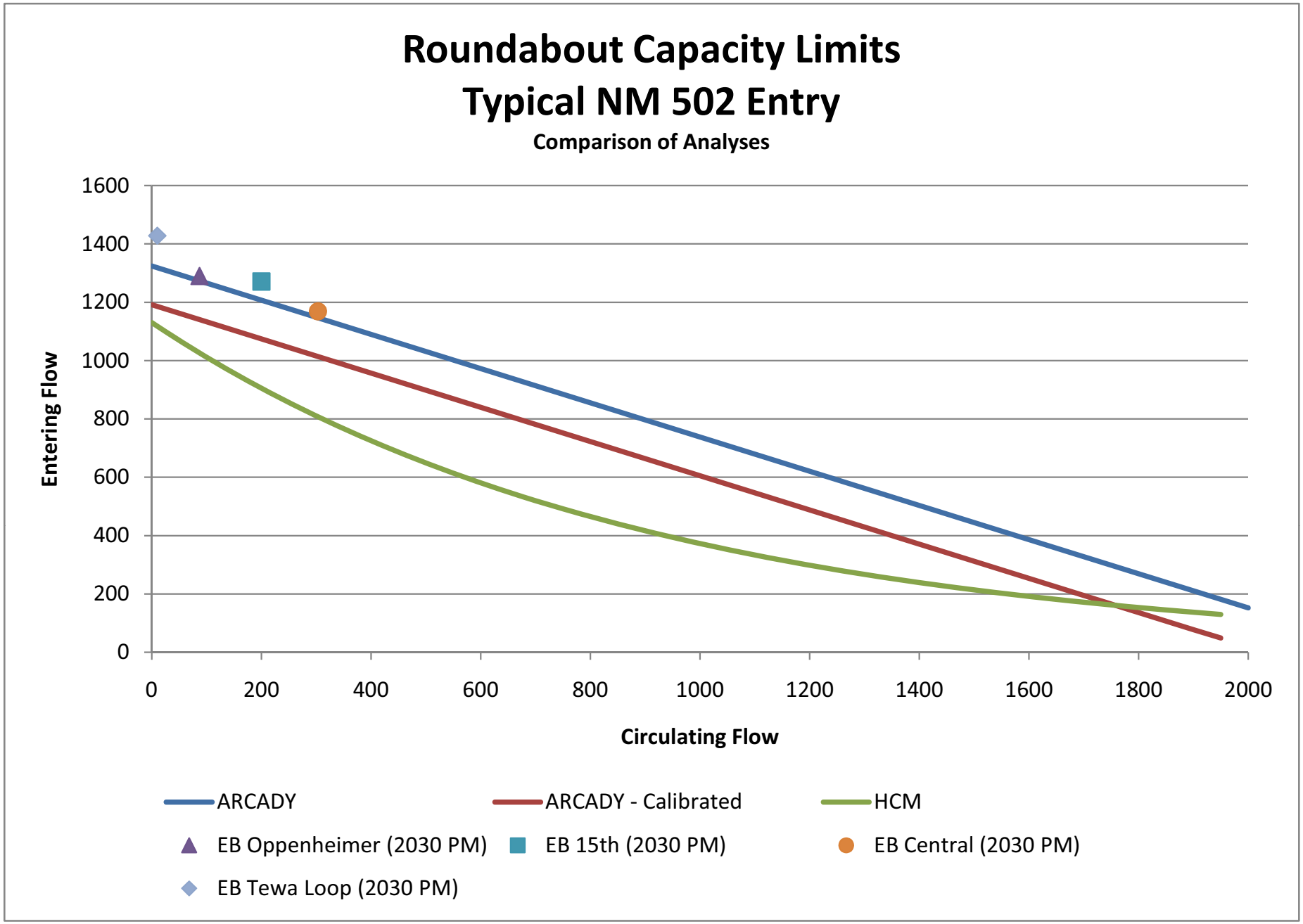
Table 4 – 4th Street ARCADY Summary

		NM 502 / 4th Street & Central							
		ARCADY Un-Calibrated				ARCADY Calibrated			
		95% Queue (ft)	Delay (Sec)	V/C	LOS	95% Queue (ft)	Delay (Sec)	V/C	LOS
2010 AM	SB 4th/Central	3	4.7	0.12	A	3	5.1	0.13	A
	EB NM 502	5	3.7	0.22	A	6	4.2	0.24	A
	WB NM 502	326	51.6	0.97	F	1076	149.3	1.08	F
2010 PM	SB 4th/Central	6	4.0	0.25	A	7	4.6	0.27	A
	EB NM 502	1337	217.2	1.13	F	1964	390.8	1.21	F
	WB NM 502	8	4.0	0.3	A	10	4.7	0.33	A
2030 AM	SB 4th/Central	4	5.0	0.16	A	4	5.3	0.16	A
	EB NM 502	7	4.0	0.27	A	8	4.6	0.3	A
	WB NM 502	2561	367.5	1.19	F	4486	701.7	1.31	F
2030 PM	SB 4th/Central	8	4.4	0.31	A	10	5.2	0.34	A
	EB NM 502	5136	978.1	1.45	F	6338	1314.4	1.55	F
	WB NM 502	11	4.4	0.37	A	13	5.3	0.41	A

Table 5 – Tewa Loop ARCADY Summary

		NM 502 / Tewa Loop							
		ARCADY Un-Calibrated				ARCADY Calibrated			
		95% Queue (ft)	Delay (Sec)	V/C	LOS	95% Queue (ft)	Delay (Sec)	V/C	LOS
2010 AM	SB Tewa Loop	1	8.2	0.05	A	1	8.1	0.04	A
	EB NM 502	7	3.8	0.28	A	8	4.5	0.31	A
	NB Tewa Loop	0	0.0	0	A	0	0.0	0	A
	WB NM 502	281	45.3	0.96	E	974	136.9	1.06	F
2010 PM	SB Tewa Loop	0	3.5	0.02	A	1	3.9	0.03	A
	EB NM 502	474	69.2	1	F	1440	198.7	1.11	F
	NB Tewa Loop	0	0.0	0	A	0	0.0	0	A
	WB NM 502	9	4.2	0.33	A	11	4.9	0.36	A
2030 AM	SB Tewa Loop	2	9.5	0.07	A	1	8.3	0.06	A
	EB NM 502	10	4.2	0.34	A	11	4.9	0.37	A
	NB Tewa Loop	0	0.0	0	A	0	0.0	0	A
	WB NM 502	2369	330.8	1.17	F	4260	666.7	1.3	F
2030 PM	SB Tewa Loop	1	3.7	0.03	A	1	4.2	0.03	A
	EB NM 502	3048	443.7	1.22	F	5336	828.1	1.35	F
	NB Tewa Loop	0	0.0	0	A	0	0.0	0	A
	WB NM 502	13	4.6	0.4	A	15	5.6	0.44	A

Figure 1


Roundabout Capacity Limits
Typical NM 502 Entry
Comparison of Analyses
Entering Flow
1600
1400
1200
1000
800
600
400
200
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Circulating Flow
ARCADY
ARCADY - Calibrated
HCM
EB Oppenheimer (2030 PM)
EB 15th (2030 PM)
EB Central (2030 PM)
EB Tewa Loop (2030 PM)