Are US 50 Roundabouts Justified based on FHWA Thresholds?

Robert W. Byren, TESA Tech Team

Abstract

In December 2023, Nevada State Governor Joe Lombardo directed the Nevada Department of Transportation (NDOT) to keep US 50 a four-lane thoroughfare from Stateline to Spooner Summit. This modified NDOT's US 50 East Shore Corridor Management Plan, or CMP, regarding lane configuration. However, other aspects of the CMP remain unaffected, including installation of two roundabouts (or traffic circles), one at the Lake Parkway intersection near Stateline and the other at the SR28 intersection near Spooner Summit. This paper assesses whether roundabouts are justified in either location, based on criteria established by the Federal Highway Administration, and identifies significant design considerations.

We conclude that the proposed mini-roundabout at Lake Parkway is not justified based on wildfire evacuation capacity and geometric constraints. We conclude that the proposed large-scale roundabout at SR28 can be justified if adequate bypass lanes along the eastbound direction of US 50 are available for evacuation. Moreover, we recommend considering an underpass configuration to better accommodate evacuation operations and to minimize left-turn delays from SR28 under normal (non-evacuation) conditions.

FHWA Justification for Roundabouts

According to the Federal Highway Administration (FHWA)[1], the first step in considering a roundabout for a particular intersection is to conduct a justification analysis and report the findings in a formal "justification report" documenting the selection of a roundabout as the "most appropriate traffic control mode" at that intersection. Nevada may use a different evaluation policy and practice, but the intent would be the same. The following are considered acceptable as justification for a roundabout by the FHWA:

Community Enhancement: "Such projects are often located in commercial and civic districts, as a gateway treatment to convey a change of environment and to encourage traffic to slow down. Traffic volumes are typically well below the thresholds [maximum traffic volume] ... ; otherwise, one of the more operationally oriented selection categories would normally be more appropriate[1]."

Traffic Calming: "The decision to install a roundabout for traffic calming purposes should be supported by a demonstrated need for traffic calming along the intersecting roadways. Most of the roundabouts in this category will be located on local roads. Examples of conditions that might suggest a need for traffic calming include:

- Documented observations of speeding, high traffic volumes, or careless driving activities;
- Inadequate space for roadside activities, or a need to provide slower, safer conditions for non-automobile users; or

- New construction (road opening, traffic signal, new road, etc.) which would potentially increase the volumes of “cut-through” traffic[1]."

"Capacity should be an issue when roundabouts are installed for traffic calming purposes only because traffic volumes on local streets will usually be well below the level that would create congestion. If this is not the case, another primary selection category would probably be more suitable. The urban mini-roundabout or urban compact roundabout are most appropriate for traffic calming purposes[1]."

Safety Improvement: "The decision to install a roundabout as a safety improvement should be based on a demonstrated safety problem of the type susceptible to correction by a roundabout. A review of crash reports and the type of accidents occurring is essential. Examples of safety problems include:

- High rates of crashes involving conflicts that would tend to be resolved by a roundabout (right angle, head-on, left/through, U-turns, etc.);
- High crash severity that could be reduced by the slower speeds associated with roundabouts;
- Site visibility problems that reduce the effectiveness of stop sign control (in this case, landscaping of the roundabout needs to be carefully considered); and
- Inadequate separation of movements, especially on single-lane approaches[1]."

Operational Improvement: **"**A roundabout may be considered as a logical choice if its estimated performance is better than alternative control modes, usually either stop or signal control. The following assumptions are proposed for a planning-level comparison of control modes:

1. A roundabout will always provide a higher capacity and lower delays than All-Way Stop Control (AWSC) operating with the same traffic volumes and right-of-way limitations.
2. A roundabout is unlikely to offer better performance in terms of lower overall delays than Two-Way Stop Control (TWSC) at intersections with minor movements (including cross street entry and major street left turns) that are not experiencing, nor predicted to experience, operational problems under TWSC.
3. A single-lane roundabout may be assumed to operate within its capacity at any intersection that does not exceed the peak-hour volume warrant for signals.
4. A roundabout that operates within its capacity will generally produce lower delays than a signalized intersection operating with the same traffic volumes and right-of-way limitations[1]."

Special Situations: **"**Some flexibility must be built into the process by recognizing that the selection categories above are not all-inclusive[1]." The primary "special situation" to be considered in selecting an appropriate control mode along the East Shore of US 50 is wildfire evacuation capacity. Any roundabout design must provide a reconfiguration mode that would allow three lanes of egress traffic with one lane of ingress traffic at maximum capacity in order to evacuate the peak summer population of the South and East Shores of Lake Tahoe, should a major wildfire threaten from the west.

Corridor Management Plan Roundabout Designs

Two roundabouts are designed as part of the US 50 East Shore Corridor Management Plan (CMP)[2], one at the intersection of US 50 with Lake Parkway at Stateline and the other at the intersection of US 50 with SR28 near Spooner Summit. In this section, we review the technical parameters for the two roundabout designs, as described in the CMP.

Stateline Roundabout Design: The configuration for the Stateline Roundabout is shown in Figure 1. The Lake Parkway intersection is a conventional four-leg configuration, with four lanes (two in either direction) on both sides of the major street and two lanes on both sides of the minor street. There is significant disparity in the traffic volume between the major and minor streets. The inscribed-circle diameter of the roundabout (measured to the edge of the roadway) is constrained by topography and adjacent structures to be approximately 91 feet, which barely exceeds the 80 foot threshold for mini-roundabouts, per FHWA guidelines[1]. This design may best be described as an "urban compact roundabout." However, because of the number of larger vehicles present on this alpine mountainous arterial (including large SUVs, large pickup trucks, RVs w/ towed autos, tractor-trailers, logging trucks, maintenance vehicles, etc.), the FHWA "empty segment" condition may still apply. That condition specifies that vehicles may not enter the traffic circle if there are vehicles in the upstream and downstream quadrants of the circle[1]. We will therefore treat this intersection design as a "mini-roundabout."

Figure 1. Configuration of CMP-Proposed Stateline Roundabout

Spooner Summit Roundabout Design: The configuration for the Spooner Roundabout is shown in Figure 2. The SR28 intersection is a 3-spoke design, since SR28 terminates at US 50, providing ample opportunity for evacuation bypass lanes along the US 50 eastbound direction. The inscribed diameter is approximately 145 feet and is not constrained by topography or existing structures. This configuration may be considered a large-scale roundabout, much like the three-leg configuration of the SR28 and SR431 roundabout near Incline Village, NV and the three-leg US 50 and SR89 roundabout near Meyes, CA. The quadrants are large enough that the FHWA empty-quadrant condition for mini-roundabouts does not apply.

Figure 2. Configuration of CMP-Proposed Spooner Roundabout

The parameters for both roundabout configurations are listed in Table 1. The justification given by NDOT for roundabout selection per the CMP is also provided.

Table 1. Design Parameters of CMP-Proposed Stateline and Spooner Roundabouts

Roundabout Parameter	Stateline Roundabout	Spooner Summit Roundabout
Presumed Configuration Type	mini	full-scale
Number of Legs	4	3
Number of Lanes per Direction (Major Street)	US 50 = 2	US 50 = 2
Number of Lanes per Direction (Minor Street)	Lake Pkwy. = 1	SR28 = 1
Independent Right Turn Lanes	no	yes
Speed Limit (Major Street)	25 mph	50 mph
Inscribed Circle Diameter	~ 91'	~ 145'
Justification	improve operations and safety	improve safety

FHWA Traffic Volume Thresholds for Roundabout Consideration

As stated above, the peak traffic volume thresholds for roundabout consideration are different depending on the type of roundabout (mini *vs.* full-scale), four- *vs.* three-leg configuration, number of lanes on the major street, proportion of traffic volume along minor street versus major street, left-turn percentage, and directional distribution (or D-factor). The FHWA thresholds are given in annual average daily traffic (AADT) or average daily traffic (ADT), therefore peak hour proportionality (or K-factor), and seasonal averaging (applicable to alpine resorts) are applied to calculate peak volume during the high season. Note that "if the volumes exceed the threshold ... , a single-lane or double-lane roundabout may still function quite well, but a closer look at the actual turning movement volumes during the design hour is required[1]."

Mini-Roundabouts: Figure 3 is taken from the Chapter 3 of FHWA publication, *Roundabouts: An Informational Guide*, and shows the AADT volume thresholds for a mini-roundabout as a function of the number of lanes and the left-turn percentage, assuming 10 percent right turns, K-factor of 0.1, D-factor of 0.58, 65 percent cross-street volume proportion, and a volume-to-capacity ratio on any leg not to exceed 0.85. These factors are described more fully in the glossary. FHWA specifies that, "for three-leg roundabouts, use 75% of the AADT volumes shown[1]."

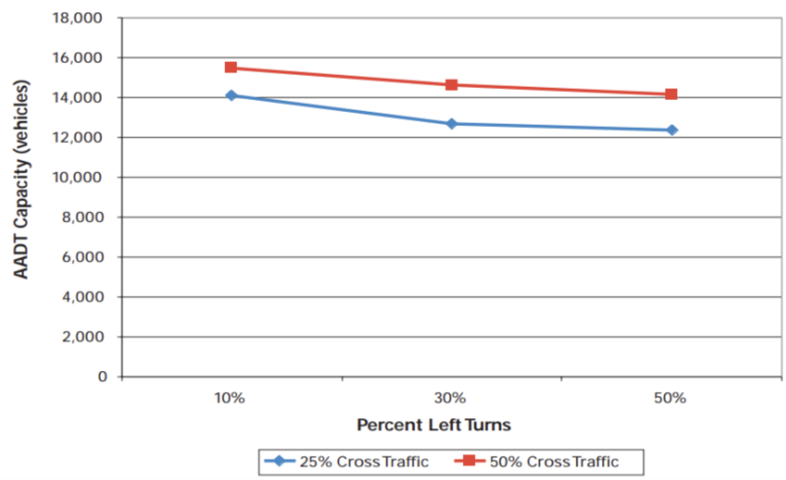


Figure 3. Maximum Daily Service Volumes for a Four-leg Mini-Roundabout.

Tables 2 shows the adjustments for the Lake Tahoe summer high season and peak hours as a function of left-turn percentage, allowing us to map the FHWA AADT volume thresholds into the measured hourly traffic flow derived from Placer.ai cell phone ping data[3] in the next segment.

Table 2. Maximum Peak-Hour Service Volume for 4-Leg, Mini-Roundabout

Configuration	Maximum Peak Volume (vph) Left Turn Percentage 10%	30%	50%
25% Cross Traffic	5873.5	5271.1	5150.6
50% Cross Traffic	6445.8	6084.3	5903.6

Full-scale Roundabouts: Figure 4, taken from the same publication, shows the AADT volume thresholds for a full-scale roundabout, given the same assumptions, except for a 50% cross-street volume proportion. Again, FHWA specifies that, "for three-leg roundabouts, use 75% of the AADT volumes shown[1]."

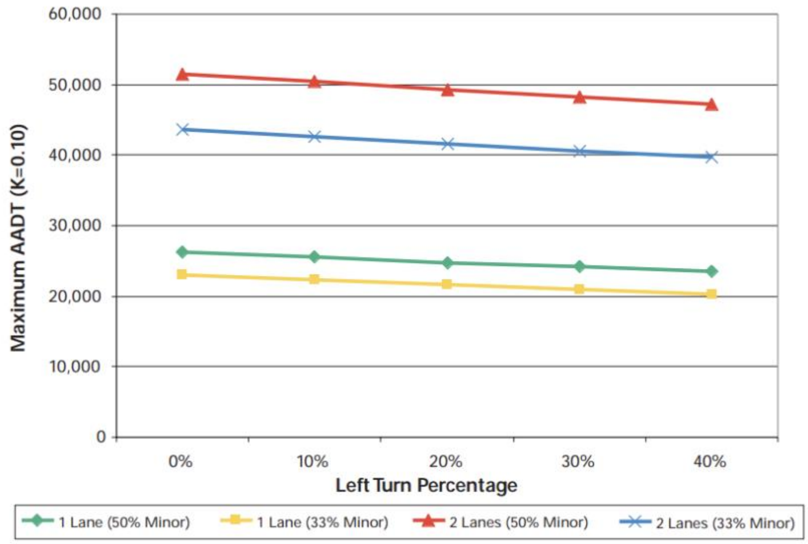


Figure 4. Maximum Daily Service Volumes for a Full-scale Four-leg Roundabout.

Tables 3 show similar adjustments for the Lake Tahoe summer high season and peak hours as a function of left-turn percentage.

Table 3. Maximum Peak-Hour Service Volume for 3-Leg, Full-scale Roundabout

	Maximum Peak Volume (vph)				
	Left Turn Percentage				
Configuration	0%	10%	20%	30%	40%
1 Lane (50% Minor)	8238.6	8025.6	7741.5	7528.4	7386.4
1 Lane (33% Minor)	7244.3	7031.3	6747.2	6534.1	6321.0
2 Lanes (50% Minor)	16051.1	15696.0	15340.9	15056.8	14701.7
2 Lanes (33% Minor)	13636.4	13352.3	12997.2	12642.0	12429.0

Measured Peak Hourly Traffic

Peak hourly traffic was measured at the Lake Parkway and Elks Point Road intersections using cell phone ping data from the Placer.ai analytics visitation database[3]. Table 4 lists the number of cell phone pings in each hour of August 30, 2021, and tabulates the relevant traffic statistics, assuming one ping equals one traversing vehicle.

Table 4. Hourly Traffic based on Placer.ai Cell Phone Ping Data

Time	Location	
	50 Hwy & Lake Pkwy, Stateline / Lincoln Highway, NV 89449, NV	**50 Hwy & Elks Point Rd, Zephyr / Elks Point Road, NV 89449, NV**
12:00 AM	2646	1734
1:00 AM	2185	1881
2:00 AM	1312	978
3:00 AM	389	318
4:00 AM	651	556
5:00 AM	1076	600
6:00 AM	978	604
7:00 AM	2414	1494
8:00 AM	2599	1844
9:00 AM	3162	2404
10:00 AM	4864	2800
11:00 AM	6794	5854
12:00 PM	6654	5270
1:00 PM	5513	4863
2:00 PM	4999	4853
3:00 PM	4850	4180
4:00 PM	2511	2267
5:00 PM	4059	2764
6:00 PM	3084	2899
7:00 PM	3216	2185
8:00 PM	2073	1150
9:00 PM	1865	1390
10:00 PM	1850	1462
11:00 PM	2518	1758
Survey Date	**9/30/21**	**9/30/21**
Design Hourly Vol, K(1)	**6794**	**5854**
Hour of DHV	**11:00 AM**	**11:00 AM**
Daily Traffic	**72262**	**56108**
Mean	**3011**	**2338**
Standard Deviation (P)	**1760**	**1553**
Apparent K-Factor	**0.094**	**0.104**

The key statistic is the peak hourly traffic which correlates to the Design Hourly Volume (DHV). Since this was derived from data for a single day of the year, use of DHV is not strictly accurate as it applies to a K(1) sample, versus K(30) as typically used. However, this is a reasonable approach given that this data sample was for an unextraordinary date within the summer high season; not the holiday periods surrounding Independence Day or Labor Day. Note that the peak value occurred at 11:00 AM for both intersections and that the peak is more than twice the mean with a K-factor near 0.10.

We use the Lake Parkway data to evaluate the capacity requirements for the mini-roundabout at that intersection. We use the Elks Point Dr. data for the SR28 full-scale roundabout. Our rationale for the latter is that Elks Point represents the highest traffic volume anywhere along the East Shore corridor east of the Kingsbury Grade intersection, noting that traffic at Spooner Summit will typically be much lower. Also, cell phone data near Spooner Summit is less reliable due to cell tower line-of-sight limitations.

FHWA Criteria Applied to CMP-Proposed Stateline Roundabout

In this section, we compare the CMP-proposed Stateline Roundabout parameters and rational to the FHWA justification criteria for roundabout consideration.

Community Enhancement: While the Lake Parkway intersection is located in a commercial/civic district and could be viewed as a gateway treatment, the traffic volume is not well-below threshold -- in fact it is near threshold for a mini-roundabout.

Traffic Calming: US 50 is not a local road, but rather a major arterial; and the traffic volume is often well above the level that would create congestion. Also, there are no parallel routes offering thoroughfare alternatives on the East Shore side.

Safety Improvement: While there is a demonstrated safety problem along the casino corridor of US 50, the issue is overwhelmingly pedestrian safety and the root cause is primarily intoxication[4,5]. This is not the type of safety problem that would be correctable by a roundabout.

Operational Improvement: The existing control mode at this intersection is All-Way Stop Control (AWSC). While a full-scale roundabout may improve capacity, the empty quadrant condition for the proposed roundabout, given the large vehicle sizes, will likely constrain capacity, as it has done at the two mini-roundabouts in Kings Beach, Ca. The measured design hourly volume (DHV) of 5854 vehicles per hour is below the 6446 vph FHWA threshold for a mini-roundabout, assuming 50% cross traffic and 10% left turns. This capacity limitation, while certainly not disqualifying, indicates the need to model the traffic modes and patterns at this intersection using a high-fidelity microsimiulation, like VISSIM.

Wildfire Evacuation: This is the main concern, since the Lake Parkway intersection is the first major East Shore bottleneck along the egress route from South Lake Tahoe, should a major wildfire threaten from the west. A four-leg roundabout configuration would be difficult to reconfigure as a three-lane egress route; and the geometric constraints of the mini-roundabout configuration would make this nearly impossible.

FHWA Criteria Applied to CMP-Proposed Spooner Roundabout

In this section, we compare the CMP-proposed Spooner Roundabout parameters and rational to the FHWA justification criteria for roundabout consideration.

Community Enhancement: The US28 intersection is not located in a commercial/civic district and is not really a "gateway" in the FHWA-described sense.

Traffic Calming: US 50 is not a local street, but rather a major arterial; and there is no need for traffic calming as intended by the FHWA. Also, there are no parallel routes offering thoroughfare alternatives for either intersecting highway.

Safety Improvement: There are incidents of serious accidents at this intersection, primarily due to inclement weather and degraded driving conditions. Speed in excess of the posted limit is not the major cause of accidents[4,5].

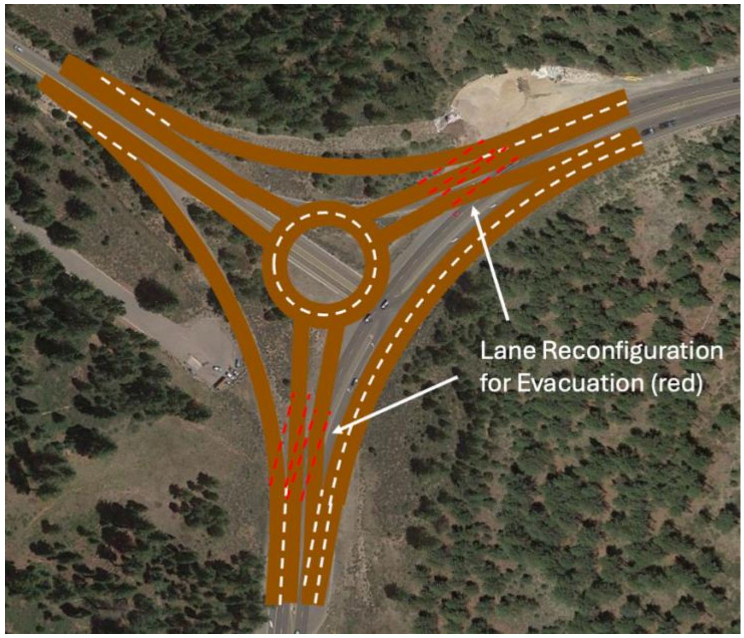
Operational Improvement: The measured DHV of 6794 vph is well below the 12,429 vph FHWA threshold for a 2-lane, 3-leg roundabout, assuming worst-case of 33% traffic in the minor direction and 40% left turns. A roundabout at this intersection would certainly improve the queuing delays, as vehicles entering along SR28 try to make a left turn onto US 50 in rush hour traffic. However, other configurations, such as an SR28 underpass, may offer better capacity in all directions. The envisioned underpass would be similar to the underpass at the three-leg Golf Club Dr. intersection on US 50 leading to Clear Creek Tahoe.

Wildfire Evacuation: The CMP-proposed three-leg two-lane roundabout is ideally suited for an evacuation scenario, as multiple Eastbound bypass lanes could be implemented without the need for a major reconfiguration in the event of a wildfire evacuation. However, this must be included in the roundabout design, currently it is not.

Notional "Evacuation-enabled" Spooner Roundabout Design

Figure 5 shows a notional full-scale roundabout design for the US 50 and SR28 intersection near Spooner Summit that accommodates three egress lanes during a major wildfire evacuation. The white dashes indicate normal lane striping. The red dashes indicate bypass reconfiguration during a wildfire, which diverts one of the westbound lanes toward the eastbound segment of the circle for egress and maintains continuity of the other westbound lane for ingress.

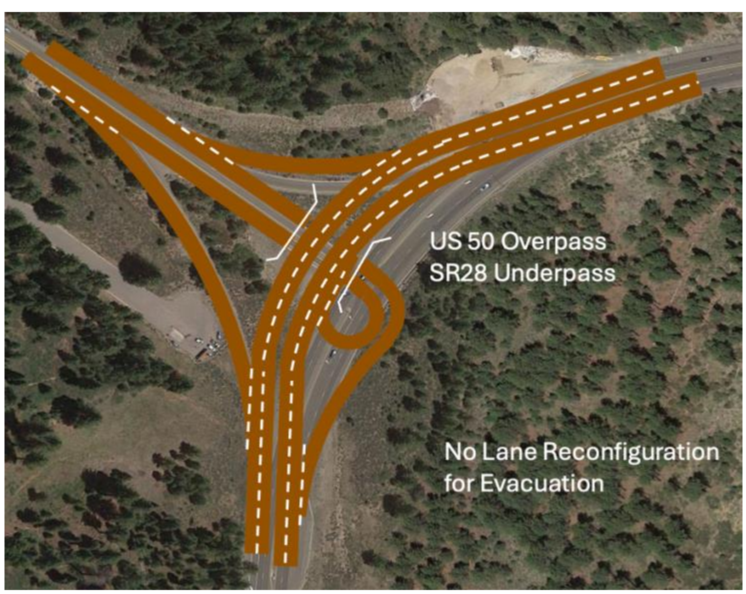
Figure 5. Evacuation-enabled Spooner Roundabout Configuration



Notional Spooner Underpass Design

Figure 6 shows a notional intersection design at Spooner Summit wherein SR28 underpasses US 50 and joins the eastbound flow via a partial cloverleaf petal. This configuration allows US 50 to flow unimpeded during both normal operation and wildfire evacuation, with no additional lane reconfiguration. It also eliminates wait time for all turns.

Figure 6. Spooner Underpass Configuration



Conclusions:

We conclude that the proposed mini-roundabout at Lake Parkway is not justified based on wildfire evacuation capacity and geometric constraints. We conclude that the proposed large-scale roundabout at SR28 may be justified if two bypass lanes are included along the eastbound direction of US 50 and a third lane can be reconfigured for evacuation egress. However, we suggest considering an underpass configuration to minimize left-turn delays on SR28.

Recommendations:

Tahoe East Shore Alliance (TESA) recommends that NDOT take the following actions before implementing roundabouts at the Lake Parkway intersection of US 50 near Stateline and/or at the SR28 intersection of US 50 near Spooner Summit:

1. Conduct a thorough Justification Analysis and publish the findings in a formal Justification Report documenting the selection of a roundabout as the "most appropriate traffic control mode" at these critical intersections, per FHWA guidelines. This should be done in light of other design approaches and control measures. For example, an underpass configuration should be considered for the SR28 and US 50 intersection, allowing free-flow to be maintained along the major route. Both the roundabout and underpass configurations would virtually eliminate serious turning accidents and many accidents attributable to degraded conditions in the winter.

2. Make the Justification Report available to the general public and accept verbal and written comment.

3. If NDOT concludes that a roundabout should be considered and would not exacerbate the traffic congestion at either intersection relative to the existing control modes, design a reconfigurable roundabout able to accommodate three lanes of egress (evacuation traffic) and one lane of ingress (firefighting and service vehicle traffic) during probable worst-case wildfire evacuation scenarios.

4. Involve community members in every phase of the design.

GLOSSARY

AADT: "... traffic volumes are generally represented for planning purposes in terms of Average Daily Traffic (ADT), or Average Annual Daily Traffic (AADT). Traffic operational analyses must be carried out at the design hour level. This requires an assumption of a K factor and a D factor to indicate, respectively, the proportion of the AADT assigned to the design hour, and the proportion of the two-way traffic that is assigned to the peak direction. All of the planning-level procedures offered in this chapter were based on reasonably typical assumed values for K of 0.1 and D of 0.58[1]."

Site-Specific Parameters: "There are two site-specific parameters that must be taken into account in all computations. The first is the proportion of traffic on the major street. For roundabout planning purposes. The proportion of left turns must also be considered, since left turns affect all traffic control modes adversely. Right turns are included in approach volumes and require capacity, but are not included in the circulating volumes downstream because they exit before the next entrance[1]."

Capacity Evaluation: "The capacity evaluation is based on values of entering and circulating traffic volumes as described in Chapter 4. The AADT that can be accommodated is conservatively estimated as a function of the proportion of left turns, for cross-street volume proportions of 50 percent and 67 percent. For acceptable roundabout operation, many sources advise that the volume-to-capacity ratio on any leg of a roundabout not exceed 0.85. This assumption was used in deriving the AADT maximum service volume relationship[1]."

K-Factor (K): "The proportion of AADT occurring in the peak hour is referred to as the peak hour proportionality K-factor. It is the ratio of peak hour to annual average daily traffic. It is used in design engineering for determining the peak loading on a roadway design that might have similar traffic volumes. For example, by applying the K-factor to a volume, a design engineer can estimate design hour volume. The K(30) is the 30th (K(100) is the 100th) highest hour divided by the annual average daily traffic[6]."

D-Factor (D): "The directional distribution factor. It is the proportion of traffic traveling in the peak direction during a selected hour, usually expressed as a percentage. For example, a road near the center of an urban area often has a D-factor near 50% with traffic volumes equal for both directions[6]."

References:

1. *Roundabouts: An Informational Guide: Second Edition*, Chapter 3, Federal Highway Administration, https://www.fhwa.dot.gov/publications/research/safety/00067/000673.pdf, pp. 58-63, 2010.

2. M. Chandler, et al, "US 50 East Shore Corridor Management Plan (CMP)," Nevada Department of Transportation, https://storymaps.arcgis.com/stories/6dac466ed89b40c68a844503f455e1d6, Oct 5, 2022.

3. T. Souza, "Hourly Impressions - 50 Hwy & Lake Pkwy, Stateline, 50 Hwy & Elks Point Rd, Zephyr - Aug 29, 2021 - Aug 31, 2021.csv", Placer.ai, November 2023.

4. R. Byren and S. Morrow, "Statistical Hypothesis Testing Applied to US 50 Accident Data," Tahoe East Shore Alliance, https://eastshorealliance.com/fact-check-us-50/, Sep. 2023.

5. R. Byren, "Corollary Statistical Hypothesis Testing Applied to US 50 Accident Data," Tahoe East Shore Alliance, https://eastshorealliance.com/what-is-probable-cause-of-most-accidents-on-us-50-east-shore-corridor/, Sep. 2023.

6. *Traffic Monitoring Guide*, Chapter 1, Federal Highway Administration, https://www.fhwa.dot.gov/policyinformation/tmguide/tmg_2013/traffic-monitoring-theory.cfm, Nov 7, 2014.

Author Biography

Robert Byren: Mr. Byren is a retired electrical engineer with over 40 years professional experience in military lasers, laser radar, beam control, adaptive optics, thermal imaging, and optical metamaterials. Prior to retirement, he served as Chief Technologist for Raytheon's Space and Airborne Systems business unit with responsibility for the senior technical staff, intellectual property, innovation, and university relations. Post retirement, he led a small consulting firm in the field of high energy laser systems. Mr. Byren holds 43 US Patents and has co-authored 55 books and technical papers. He received his MSEE degree from Stanford University in 1975 and his BSEE degree from Lehigh University in 1974.