

Roundabouts and Signals: Harmony Even with Increasing Traffic Volumes

CURRENT GUIDANCE SUGGESTS AVOIDING THE PLACEMENT OF ADJACENT TRAFFIC SIGNAL AND ROUNDABOUT CONTROLLED INTERSECTIONS. HOWEVER, PRACTITIONERS ARE OFTEN FACED WITH JUST SUCH A SITUATION, AND LITTLE GUIDANCE IS AVAILABLE. THIS FEATURE DOCUMENTS THE PERFORMANCE OF THE EBY CREEK ROAD CORRIDOR, WHICH HAS A ROUNDABOUT, TWO TRAFFIC SIGNALS AND TWO STOP-CONTROLLED INTERSECTIONS.

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INTRODUCTION

It is true—a roundabout’s performance is affected by its proximity to a signalized intersection, but isn’t the performance of a signal at that same intersection also affected by that adjacent signalized intersection?

Signalized intersections can work together to provide traffic progression along a corridor. When improperly placed or operated, they can work against each other to create congestion and gridlock. Traffic peaking and flow characteristics are dynamic and location-dependent. Achieving optimal flow requires consideration of all the options within the intersection alternative toolbox (roundabouts, traffic signals and STOP signs). Many practitioners are reluctant to consider a roundabout adjacent to a signalized intersection because of the doubt many of the roundabout guidance documents cast on the notion. In reality, a roundabout may be the best alternative for the location.

Roundabouts, signals and STOP signs can co-exist along the same corridor with the proper analysis and evaluation of the corridor, not only an analysis of a series of isolated intersections. Figure 1 shows a roundabout downstream from a signalized intersection in Eagle, CO, USA.

CONSIDERATIONS FOR ROUNDABOUTS AND SIGNALS ON THE SAME CORRIDOR

The compatibility of adjacent and different intersection types is a function of demand and local conditions (intersection traffic volume characteristics, turning demands, intersection spacing, existing adjacent traffic control and available right of way). However, limited published research is available on this topic. Bared and Edara performed an evaluation of a corridor with three one-quarter-mile spaced intersections and two through

lanes in each direction using VISSIM, a microscopic simulation program.¹

The study compared two scenarios consisting of three coordinated signals versus two signals and a roundabout in the middle. Signalized intersections included two through lanes and one exclusive left- and right-turn lane under a 60-second cycle length. The roundabout was evaluated as a two-lane roundabout.

The findings showed that when the system was operating below capacity, the roundabout scenario resulted in less delay. When the corridor approached capacity, the all-signal scenario resulted in slightly less overall delay. Although this was a hypothetical scenario, the findings show the importance of considering multiple volume scenarios when evaluating mixed intersection alternatives.

Arrival and Departure Patterns

The arrival and departure patterns of traffic at signalized intersections and roundabouts are naturally different. Vehicle platoons form at signalized intersections; traffic is typically dispersed randomly at a roundabout. Intersection spacing between the signal and the roundabout determines whether traffic will remain in a platoon or will be dispersed. The volume of the arriving platoon and the capacity of the roundabout will dictate the ability of the roundabout to service the platoon.²

Additionally, the ability of the roundabout to service the platoon, as a platoon, is dependent on the other roundabout approach volumes and subsequent turning movements. It is possible that priority sharing will occur between the entering and circulating volumes. In this case, the platoon will be dispersed at the roundabout, which may or may not be of concern depending on the intersections downstream. The random departures of traffic leaving a roundabout may affect the ability of traffic at adjacent unsignalized intersections or driveways.

A roundabout within a series of coordinated signalized intersections has the potential to break down the platoons created along the corridor, which may defeat the purpose of the coordinated corridor. However, a roundabout has the potential to alleviate congestion at a critical intersection along the coordinated network (i.e. the intersection with the longest cycle length), allowing the remainder of the coordinated signals to operate at a more effective cycle length.

Intersection Spacing

Traffic and design engineers appear to be more comfortable with a corridor of signalized intersections (coordinated or uncoordinated) and stop-controlled intersections as opposed to a corridor with a mix of roundabouts, traffic signals and stop-controlled intersections. Typical minimum recommendations for signalized intersection spacing are not less than one-quarter-mile (1,320 feet) to allow for the most efficient traffic flow.^{3,4,5} A corridor with signals less than one-quarter-mile apart is more likely to develop delays and queues at the intersections.⁶ Regardless of these minimum recommendations, roadway networks are littered with traffic signals less than one-quarter-mile apart.

Spacing guidance for a roundabout in series or within a network of intersections often uses vague language, such as intersections that are “too closely spaced” or “very close” or “in close proximity to one another.” This indistinct terminology can include a wide range of distances. The relevant appropriateness is clearly a function of traffic volumes, turning movements, adjacent traffic control and available right of way. Roundabouts have the potential to bring order to closely spaced intersections.

95th-Percentile Queues

Estimating the 95th-percentile queues for each approach is one of the first steps in determining whether the intersections are “too close,” and the up- and downstream impacts both should be considered. It is critical to establish if adequate spacing between intersections exists, as queues should be contained between the intersections.^{7,8} The 95th-percentile queue is the queue expected less than 5

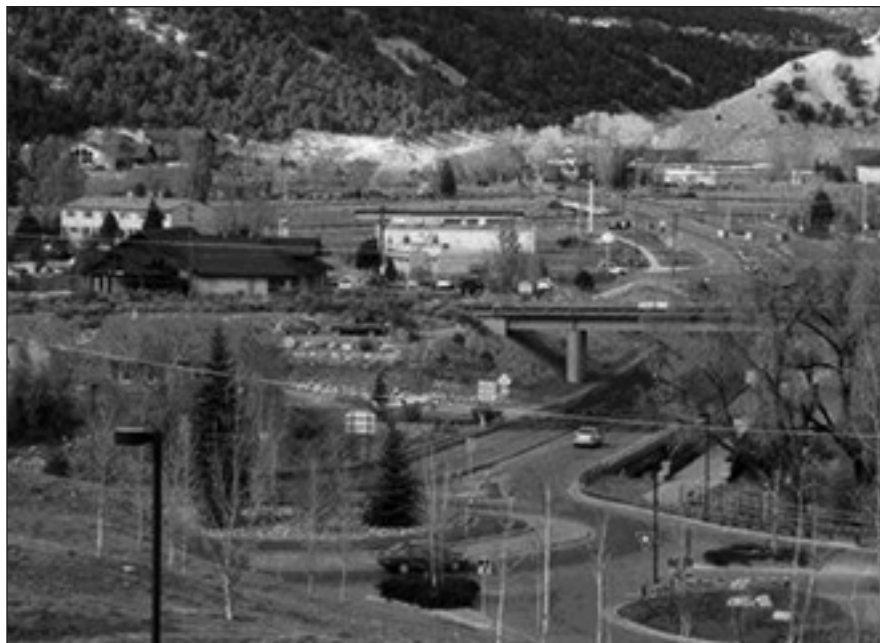


Figure 1. Roundabout 850 feet downstream of a signalized intersection.



Figure 2. Eby Creek Road corridor in Eagle, CO, USA.

percent of the time during the analysis period at an unsignalized intersection or less than 5 percent of the signal cycles during the analysis time period at a signalized intersection.⁹

EBY CREEK ROAD CORRIDOR

The Eby Creek Road corridor in Eagle is a good example of where a mixture of traffic control strategies has been used to address growing traffic demands and unique local conditions.

Background

The Town of Eagle has seen its population increase from 1,580 in 1990 to 3,032 in 2000.¹⁰ The current population is estimated to be between 5,000 and 6,000, an almost 100-percent increase in the last eight years.^{11,12} The Town of Eagle’s largest employer is Eagle County.

Many Eagle residents work outside of town, which results in a surge of vehicles leaving Eagle (headed east on Interstate 70) in the morning and returning in the



3a. Looking west along US 6.



3b. Looking north from US 6 roundabout to the Chambers Avenue signalized intersection.



3c. Looking east down the Interstate 70 exit ramp at traffic queued at the Eby Creek Road signalized intersection.

Figure 3. Eby Creek Road p.m. peak traffic congestion.

afternoon. A significant influx of traffic from outside of Eagle also inundates the Eby Creek Road corridor daily. In 1998, the three major intersections on the corridor—US 6, Chambers Avenue and the Interstate 70 westbound ramp terminal—served 1,260 vehicles, 1,350 vehicles and 1,330 vehicles, respectively, during the p.m. peak hour.

The existing structures along the Eby Creek Road corridor limit the options to improve operations without constructing new, wider bridges. The bridges over the Eagle River, the Union Pacific Railroad underpass and the Interstate 70 overpass are each limited to three lanes of travel.

The Town of Eagle installed its first two traffic signals in 2000 at the intersections of Eby Creek Road and Chambers Avenue and Eby Creek Road and the Interstate 70 westbound ramp terminal. The following year, a single-lane roundabout was constructed at the intersection of US 6 and Eby Creek Road. The 0.4-mile corridor includes five major intersections and two minor intersections. The five major intersections include a single-lane roundabout, two traffic signals and two two-way stop-controlled intersections. The two minor intersections provide right-in-right-out access to businesses. Figure 2 shows the intersection spacing along the corridor.

The roundabout at the US 6 intersection provided the town with a feasible intersection alternative at a location with multiple physical constraints and two dominant turning movements. The signalized alternative would have required an intersection footprint (dual left-turn lanes and turn-lane storage on each approach), which was not practical at this location.

Performance under Increasing Traffic Volumes

The corridor experienced improved operations during the five years after the roundabout was constructed. The roundabout handled the heavy southbound right-turning and eastbound left-turning movements with minimal delays.

By 2005, several turning movements at one of the signalized intersections (Chambers Avenue) began experiencing delays (waiting through multiple signal cycles) during the morning and evening peaks.

Currently, congestion along the corridor is regular with traffic queuing down the Interstate 70 ramp and along the shoulder of Interstate 70 as well as along the entire Eby Creek Road corridor. Figure 3 shows current queuing and congestion.

Traffic volumes have continued to increase at a rate of approximately 5 percent per year along the corridor.¹³ The 2008 traffic counts showed volumes along US 6 near 19,000 vehicles per day; Eby Creek Road near 19,300 vehicles per day between US 6 and Chambers Avenue and 13,600 vehicles per day between Chambers Avenue and Interstate 70 eastbound ramp terminals; and 6,200 vehicles per day over the Interstate 70 bridge.

The US 6 roundabout and the Chambers Avenue signalized intersection both service approximately 2,100 entering vehicles during the p.m. peak hour. The signalized Interstate 70 westbound ramp services approximately 1,500 entering vehicles during the p.m. peak hour. For the US 6 roundabout, 70 percent of the peak-hour traffic, both a.m. and p.m., is contained within two traffic movements, southbound right and eastbound left.¹⁴

Corridor Performance at Capacity

It is clear that the Eby Creek Road corridor is operating near capacity during the p.m. peak with several movements over capacity during the p.m. peak. As is often the case, several contributing factors led to the poor peak-hour operations, including:

- sub-optimal signal timings;
- substandard signal spacing (the signalized intersections are just over one-eighth-mile apart, nearly half the recommended minimum for signal spacing, which also likely contributes to queuing and delays);
- heavy commuter patterns and interstate influence;
- heavy southbound right-turning and eastbound left-turning volumes at the US 6 roundabout; and
- lack of intersections working together to create an efficient flow of traffic.

Some of the public's perception of the congestion on the corridor points to the roundabout. Apparently drivers are used to stopping and waiting at traffic signals, but when they are stopped in a roundabout, they think the roundabout is failing, not



4a. Looking south toward roundabout.



4b. Looking north to signalized intersection.

Figure 4. Eby Creek Road a.m. peak traffic congestion.

the upstream traffic signal. For the conditions noted above, the peak-hour queuing that occurs within the roundabout is a direct result of substandard signal operations at the Chambers Avenue signalized intersection. Figure 4 shows back-ups from the Chambers Avenue signalized intersection to the US 6 roundabout. Although the roundabout may be contributing to a portion of the peak-hour delay, it is not the source of the poor peak-hour operations.

The Future of the Eby Creek Road Corridor

The significant growth in traffic demand points toward an eventual complete overhaul of the corridor, but for now a few low-cost (relatively speaking) alternatives

will provide much-needed peak-hour capacity to the corridor.

The short-term plan laid out by the Town of Eagle and Colorado Department of Transportation includes:

- adding a second approach lane (right only) on the north approach of the roundabout to increase flow of the dominant southbound right-turn movement;
- providing protected left-turn phases for all approaches at Chambers Avenue;
- optimizing and coordinating each of the signalized intersections; and
- extending the storage length for the northbound right-turn lane at Chambers Avenue.



Figure 5. Capacity improvements along Eby Creek Road completed October 2008. Looking south at the US 6 roundabout with added approach lane to accommodate heavy right-turn movement.

Modifications to the corridor are already underway, as shown in Figure 5. The future will continue to bring more traffic to this corridor with the expected growth in and around the Town of Eagle. Intersection capacity can be maximized with roundabouts with minimal impacts to the existing intersection approach widths. Although the footprint for a single, hybrid (one-two lane) or two-lane roundabout at the intersections may encroach outside the existing right of way, approach storage is not necessary for left- and right-turn lanes.

Avoiding the construction of new bridges also has the potential to save project costs by an order of magnitude. Introducing a series of roundabouts on this corridor to preserve the existing corridor width and avoid the unnecessary and costly replacement of three bridges may be the ultimate solution to address the physical constraints and growing traffic volumes.

SUMMARY

Eby Creek Road provides a case study to examine the performance of a roundabout as part of a traffic signal controlled corridor under growing traffic demand conditions. From perception to analysis of operations at capacity, the limitations of either type of traffic control can be considered. The case study is also realistic as the local agency tries to address immediate needs and consider future fiscally-restrained options. Could the entire cor-

ridor operate using roundabouts, traffic signals, or some unique combination of the two? Mutually exclusive choices are clearly not today's status quo.

Searching for a black-and-white approach and/or answers when it comes to roundabouts and signals on the same corridor is a waste of time. Roundabouts can live in harmony with traffic signals, but the key is to perform a corridor analysis with all the key intersections and access points. A corridor analysis can provide the optimal traffic control at an intersection as well as for efficient operations along the corridor. When considering a roundabout as an intersection alternative, proximity to signalized intersections should not be a deal breaker. It is essential that considerations for traffic volumes and turning movements, intersection spacing, existing adjacent traffic control, queuing, available right of way and corridor footprint be included in performing a sound and holistic corridor analysis. ■

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