Comparative Analysis: Roundabout vs. Signalized Intersection

Second Avenue at Scarlett Road

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Background Information

The City of Greater Sudbury (City) is currently undertaking a Transportation Master Plan that identified the need to widen Second Avenue between Scarlett Road and Donna Drive. The City then scheduled a reconstruction and widening of Second Avenue from Donna Drive to Kenwood Street for the 2014 construction season (see Figure 1). The limits of the project have since been extended south to First Avenue to address drainage and cycling infrastructure connectivity issues that were identified during detailed design. As part of the reconstruction, a traffic signal warrant analysis indicated that a signalized intersection be built at Second Avenue and Scarlett Road. Part of the signalization of this intersection would include combining the entrance to the Civic Memorial Cemetery and the Minnow Lake Dog Park and aligning this new entrance across from Scarlett Road. The City considered the construction of a roundabout at this location, and formalized the process with this report. The City does not have a formal process for reviewing traffic control options for intersections prior to detailed design.

Figure 1- Project Location

Description of Alternatives

The City of Greater Sudbury's Transportation Master Plan has identified the need to widen Second Avenue based on projected traffic volumes. The scheduled capital project proposes to widen Second Avenue to a five lane cross section (two thru lanes for northbound (NB) traffic, two thru lanes for southbound (SB) traffic and a centre two way turning lane). In addition, it is proposed that the entrance to the Civic Memorial Cemetery and the Minnow Lake Dog Park be combined into one entrance that is aligned with Scarlett Road. The intersection control alternatives were developed based on these proposals.

Signalized Intersection

The proposed signalized intersection configuration is as follows:

- Second Avenue SB Approach – one right-turn (RT) lane, two thru lanes, one left-turn (LT) lane
- Second Avenue NB Approach – one thru lane, one shared thru/RT lane, one LT lane
- Scarlett Road Westbound (WB) Approach - one shared thru/RT lane, one LT lane
- Cemetery/Dog Park Entrance Eastbound (EB) Approach - one shared thru/RT lane, one LT lane

Roundabout

The proposed roundabout configuration allows for two lane approaches for the NB and SB legs and one lane approaches for the EB and WB legs. Due to the two lane approaches for Second Avenue, the roundabout requires a two lane configuration. The *National Cooperative Highway Research Program (NCHRP) Report 672 – Roundabouts: An Information Guide – Second Edition* indicates that the typical inscribed circle diameter for a multilane roundabout ranges from 46 m to 91 m. A conceptual design indicates a roundabout with a 55m ICD (Waterloo guidelines) will function at this intersection with 9.1 m road width.

Intersection Capacity

Capacity analysis for 2031 traffic volumes was completed in Synchro for the signalized intersection and Arcady for the roundabout.

The analysis indicates that each type of intersection traffic control will operate at a high level of service at the projected 2031 traffic volumes. Additionally, all approaches to the intersection will operate below a 0.5 volume to capacity ratio, which is an acceptable level of service.

Right-of-Way Requirements

Signalized Intersection

The proposed signalized intersection configuration can be accommodated within existing 30 m wide right-of-way limits. No additional property would be required, nor would access to the commercial strip mall located in the southeast corner of the site be affected.

Roundabout

A roundabout with a 55 m ICD cannot be accommodated within the existing right-of-way limits. The location of the roundabout is further restricted due to the strip mall in the southeast corner of the intersection. It will be extremely difficult to acquire additional property from this site without severely impacting the parking lot and access. To avoid this property restriction and potential expense in expropriation, the centre of the intersection will have to be shifted approximately 15 to 20 metres west. This will require horizontal curves be added both north and south of the intersection to properly align the NB and SB approaches, requiring approximately 30 m of additional road length. Additional property will be required to realign Second Avenue. In addition, the internal roads to the cemetery and dog park will need to be realigned to provide a safe approach to the roundabout, further impacting the property.

While the property being impacted to the west is owned by the City, it is the City's only cemetery with available room for burials. The City recently went through a property expropriation process to acquire additional lands to the south to expand the cemetery. Any use of these lands will impact the available capacity and shorten the expected life of the cemetery. The appraised cost of these lands is estimated at approximately $200,000.

Costs

Typically, the construction costs for pavement, grading, drainage, etc, are similar for both types of intersection traffic control. In terms of the roundabout, there will be additional costs associated with the realignment of the Second Avenue and the internal roads for the cemetery and dog park. The additional construction cost for a roundabout in comparison to a signalized intersection for the road portion only is estimated at $400,000. This does not include an allowance for the internal cemetery and dog park road realignment, work within the center of the roundabout, or the restoration and grading of the impacted area. Additional costs are also anticipated for temporary traffic staging during construction, as Second Avenue will have to remain open to traffic. Without a detailed design, the estimated additional cost of the roundabout will likely be in excess of $500,000.

The estimated cost for the traffic signal plant is $200,000. Annual maintenance costs for a signalized intersection are between $4,000 and $5,000. It is expected that annual maintenance costs for a roundabout will be limited to maintaining landscaping features and the additional asphalt surface.

Including the cost for the property impact above, it is estimated that the roundabout will cost approximately $500,000 more than the signalized intersection.

Safety

Pedestrian Safety

The design characteristics at a roundabout encourage pedestrian safety and visibility. The crosswalk is located one car-length behind the yield line at the entrance to the circulatory roadway. This allows the driver to address one conflict at a time: first, the pedestrian crosswalk, and second, identifying a gap in the circulatory roadway to enter the roundabout itself. The same is true at the roundabout exit: the driver first identifies his exit and leaves the circulatory roadway, and then identifies and addresses the pedestrian crosswalk. The crosswalk is properly signed and marked for the approaching vehicle. Proper lighting of the crosswalk also ensures that pedestrians are visible in nighttime conditions and are not backlit.

British statistics have shown that pedestrian collision rates at roundabouts are just over 50% less than those at signalized intersections. This is primarily due to two key geometric features: first, pedestrians must only cross one direction of traffic at a time and have a refuge at the median splitter island; and second, all vehicular turning movements at a roundabout are merged into the circulatory roadway and require pedestrians to be aware of only one movement at a time. For example, when crossing the direction of traffic approaching the roundabout, pedestrians only need to be aware of vehicles approaching. When crossing on the opposite side of the roadway where vehicles are exiting the roundabout, pedestrians only need to be aware of the lane(s) of traffic from the circulatory roadway exiting towards the crosswalk. Whereas, at a signalized intersection, pedestrians crossing the exiting lane of the intersection must be aware of through vehicle traffic, left turning traffic, and right turning traffic since all vehicles begin the turning movement from a different location.

People who are visually impaired may experience difficulty using roundabout crosswalks, particularly where traffic volumes are high. Roundabouts, like channelized turn lanes, present challenges different from other intersections since the traffic is most often under yield control as opposed to stop control. It is difficult to be sure that traffic will yield to pedestrians, and the continuous circulation of vehicles makes it difficult for the visually impaired to determine significant gaps in traffic movements. In addition to determining when to cross the road, pedestrians with vision impairment must identify where to cross, which way to walk during the crossing, and when they have arrived at their destination curb or island (reference MTO website: http://www.mto.gov.on.ca/english/engineering/roundabout/faq.shtml#7)

During the public input process there were many concerns raised about the ability of pedestrians crossing, especially for children and seniors.

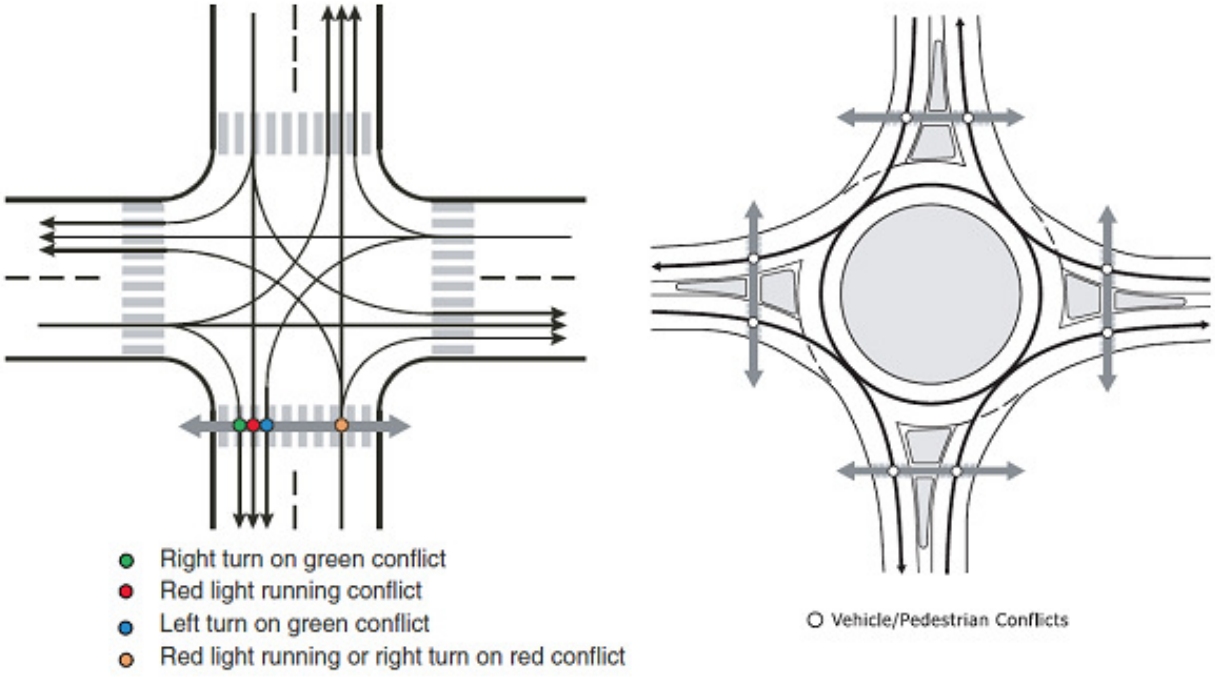

Figure 2 - Pedestrian Vehicle Conflict Points

Vehicle Safety

Studies completed in the United States have shown a significant decrease in collisions and personal injury collisions for intersections that have been converted from signal-controlled to roundabouts. The statistics show a 48% reduction in overall collisions and a 78% reduction in personal injury or fatal collisions as per *NCHRP Report 572*. This can be explained by the reduction of the number of vehicle conflict points and the elimination of crossing conflicts. Crossing conflicts occur where the paths of two traffic streams intersect. These are the most severe of all conflicts and the most likely to involve injuries or fatalities. These collision types are typically right-angle collisions and head-on collisions. As shown below, the number of vehicle-vehicle conflict points in a roundabout are reduced as much as 75% from a signalized intersection. In the last three years, there has only been one collision at this unsignalized intersection.

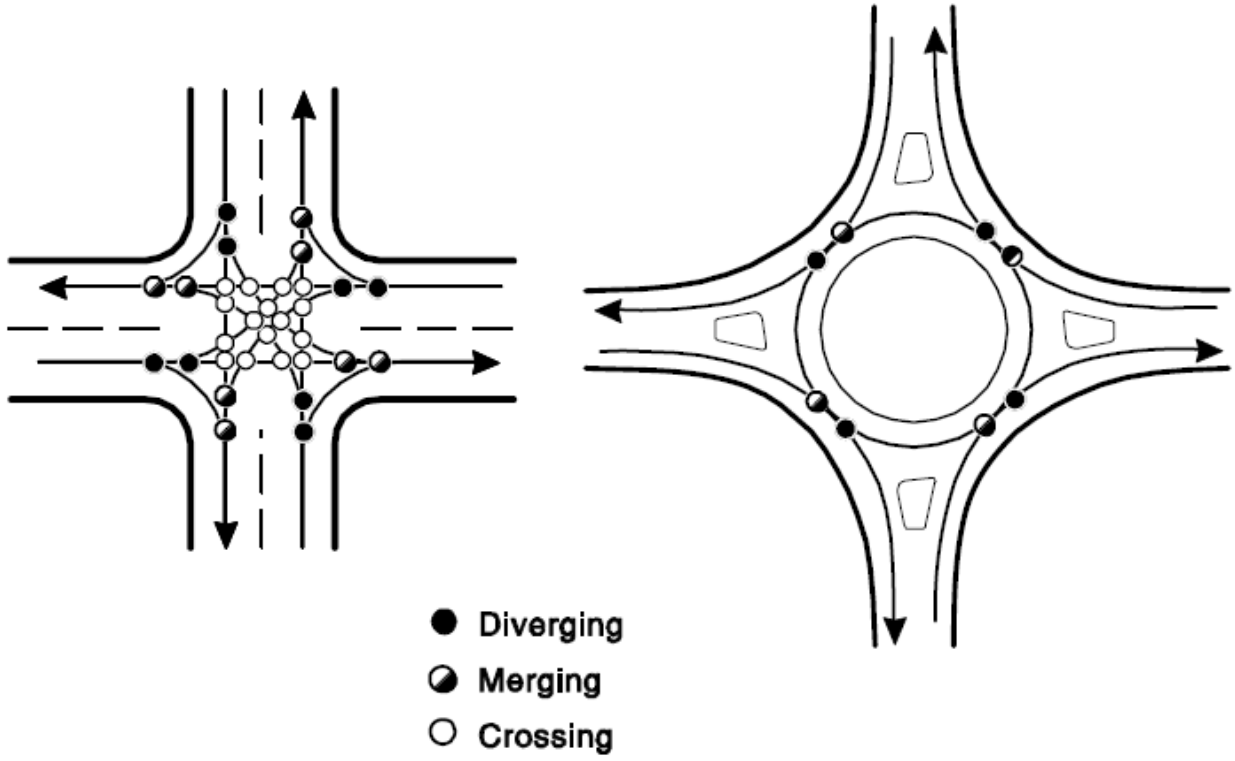

Figure 3 - Vehicle Conflict Points

Bicycle Safety

A raised cycle track is proposed for Second Avenue. The cycle track begins south of Donna Drive and continues to Kenwood Drive. As a result, cyclists will need to be accommodated through the Second Avenue at Scarlett Road intersection

Roundabout

Cyclists face similar conflicts as motor vehicles at both signalized intersections and roundabouts. However, because cyclists typically ride on the right side of the road between intersections, they face additional conflicts when they need to merge into the flow of motor vehicle traffic or where motor vehicles cross their path.

Many of the additional conflicts experienced by cyclists vary depending on how they choose to negotiate the intersection. Multi-lane roundabouts can be navigated in the center of the lane (in the middle of the roadway), on the outer edge of the lane or on the sidewalk (dismounted). Also, navigation can be done either in the correct lane (any lane other than the outside lane) or in the incorrect lane (typically the outside lane).

Figure 4 below shows the conflicts a cyclist in the correct lane encounters when riding in the center of the lane (solid line) and when riding on the outer edge of the lane (dotted). There is only one conflict point when the car is exiting and the bicyclist is continuing.

Figure 4 - Navigating a Multi-Lane Roundabout on the Outside Edge of the Lane

Figure 5 below depicts the movements of bicyclists in the center of their lane (in-lane) for a left turn movement and the resulting conflicts. As can be seen, the movement in the correct lane (inner lane) does not result in any conflicts. A bicyclist using the incorrect lane (outside lane) results in conflicts when being passed by motorists, path overlaps and at the exits. The figure also depicts how a bicyclist can use the sidewalk to pass through a roundabout.

Figure 5 - Navigating a Mulit-Lane Roundabout In-Lane (Correct and Incorrect Lanes)

Signalized Intersection

For a signalized intersection, a Cross Ride is being proposed. It allows cyclist to ride their bicycle within the crossing without dismounting. As shown in Figure 6 below, a Cross Ride is typically provided between the crosswalk and the through lane of traffic. Cyclists approaching the intersection are required to obey the traffic signal display and only proceed on a green indication. This layout separates cyclists from vehicles through the intersection and eliminates sideswipe type of collisions. However, merging conflicts will remain with left turning and right turning vehicles.

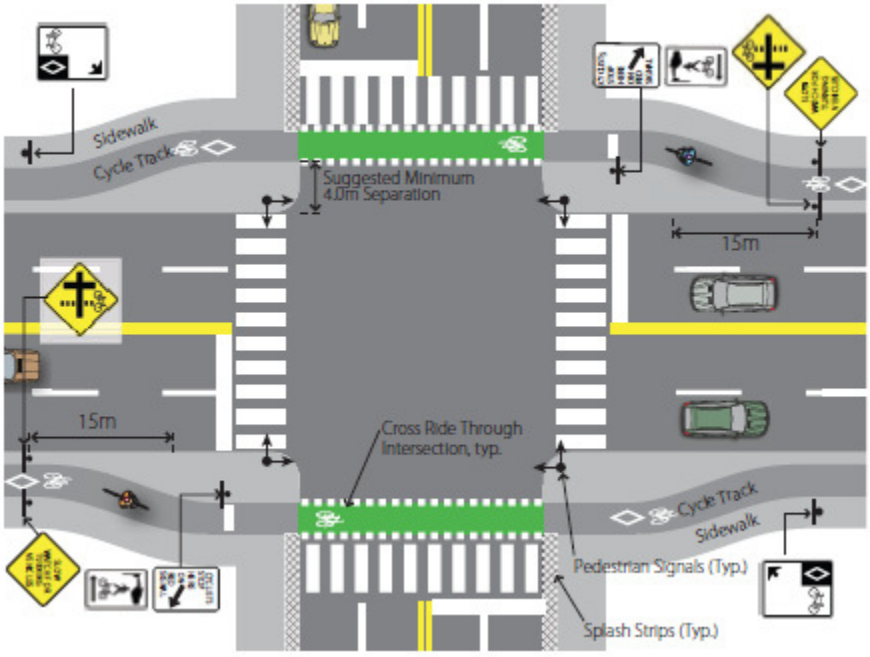

Figure 6 - Typical Cross Ride at a Signalized Intersection

The cycling facilities provided for both the roundabout and signalized intersection will be new to cyclists in the City of Greater Sudbury. However, for a multi lane roundabout, research has shown that only the most confident and experienced cyclists will attempt to ride through the intersection. Most others will be intimidated and utilize the sidewalk instead. Utilizing the sidewalk creates additional conflicts with pedestrians. The proposed Cross Ride will integrate with the raised cycle track and should be less intimidating for less experienced cyclists.

Driver Familiarity

Only one single lane roundabout has currently been installed in the City of Greater Sudbury and it is at the intersection of three local roadways, all with low traffic volumes and within a new subdivision. The majority of City of Greater Sudbury drivers will not be familiar with how traffic navigates through a roundabout.

With over 120 traffic signals installed within CGS, local drivers are very familiar with signalized intersections.

The City is currently designing the Maley Drive Extension with roundabouts. Maley Drive is a primary arterial road and is meant to divert truck traffic around the City. Prior to this, the City understands that an educational campaign will be required to educate local residents on the use of roundabouts. There are also other projects where roundabouts are being considered throughout the City.

Environmental

When operating within their capacity, roundabouts typically operate with lower vehicle delays that signalized intersections. With a roundabout, it is not necessary for traffic to come to a complete stop when no conflicts are present. When there are queues on one or more approaches, traffic within the queues usually continues to move. The performance of roundabouts during off-peak hours is particularly good when compared to signalized intersections, usually with very low average delays.

These lower vehicles delays translate to increased fuel savings, reduced green house gases and reduced vehicle noise.

Summary of Findings

A summary of the analysis is presented in the following table.

Table 1 - Comparative Ratings

	Roundabout	Signalized Intersection
Capacity	=	=
Right of Way Requirements	-	+
Construction Costs	-	+
Maintenance Costs	+	-
Pedestrian Safety	=	=
Vehicle Safety	+	-
Cyclist Safety	-	+
Driver Familiarity	-	+
Environmental	+	-

Comparative Ratings: + (Advantage); - (Disadvantage); = (equal or no significant difference)

Based on the conceptual design, installing a roundabout at the intersection of Second Avenue and Scarlett Road will be very challenging. The restricted right-of-way in the southeast corner of the intersection would require the entire intersection be shifted to the west. This in turn would require a realignment of the northbound and southbound approaches of Second Avenue to properly align with the roundabout. Additionally, the internal roads for the Civic Memorial Cemetery and Minnow Lake Dog Park would need to be realigned to provide a safe and functional approach to the roundabout.

Although in general there is an increased benefit to vehicle safety by utilizing a roundabout instead of a signalized intersection, there has only been one reported angle type collision in the last three years at this intersection. In terms of cyclists, a raised cycle track is being provided as part of the reconstruction of Second Avenue to provide a separated cycling facility. With the roundabout design, those who do not want to dismount their bicycle will be required to merge into traffic to negotiate the roundabout. Under the signalized intersection design, cyclists will remain separated from the thru traffic although they will

still be exposed to left and right turning vehicles. Under these circumstances, it is believed cyclist safety will be enhanced with a signalized intersection.

Although there are some benefits to a roundabout compared to a signalized intersection, they do not outweigh the increased construction costs, the impact to adjacent property owners (Cemetery and commercial mall) and the decreased safety for cyclists. It is recommended a signalized intersection be provided at the intersection of Second Avenue at Scarlett Road.