Canada's First Modern Roundabout Interchange: A Study in Success at King Street – Fort McMurray, Alberta

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Paper prepared for presentation at the "Innovative Intersection & Interchange Designs" session of the 2004 Annual Conference of the Transportation Association of Canada (TAC)
Quebec City, Quebec

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ABSTRACT

Highway 63 is the main north/south route through Fort McMurray, Alberta, one of Canada's fastest growing cities. The highway was originally completed in the 1970s, and was designed to service a population of roughly 25,000. The intersection of Highway 63 and King Street was an at-grade unsignalized two-lane road that generated unacceptable traffic accident statistics. As early as 1991, designs had been put forward to improve the operation and safety of this intersection. By 1999, traffic through the intersection was approaching 20,000 vehicles per day (1) and accident statistics were increasing. Although the Municipality had engaged an engineering firm to design a new interchange, they lacked the funds (even with provincial cost sharing) to proceed with construction.

In 2000, Alberta Transportation took over all primary and secondary highways in the province to improve operations and maintenance, provide connectability and safety to the system, and directly alleviate costs for cash-strapped municipalities. The province recognized the need to improve the Highway 63/King Street intersection, assigned a high priority to it, and proceeded with the functional planning, design, and construction of a new interchange.

This paper demonstrates the inability of diamond, modified diamond, and trumpet interchange designs to meet all the requirements of the Highway 63/King Street intersection. The traditional interchange designs had several operational shortcomings, required recreational property acquisition, and intruded unacceptably on the environment. After researching various types of intersections and interchanges, the engineers and Alberta Transportation agreed to construct a modern roundabout (similar to the traditional traffic circle) at the end of a straight overpass of Highway 63. The unique design provides for improved traffic flows and best meets all other requirements. This is believed to be the first modern "roundabout" interchange in Canada. The overpass and roundabout have been in operation for almost one year.

This paper provides details on the decision to implement the roundabout design. It also demonstrates the suitability of roundabout designs in Canada and provides a design framework for interchange-type decisions for other jurisdictions considering difficult or unique applications in their own road network.

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by

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and
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BACKGROUND

History of the Study Area

The Regional Municipality of Wood Buffalo was established on April 1, 1995, through the amalgamation of the City of Fort McMurray and Improvement Area No. 143. The Regional Municipality covers over 68,400 square kilometers, making it one of the largest municipalities in North America. It encompasses some of the largest oilsands deposits in the world, estimated to contain over 1.3 trillion barrels of oil.

The urban service area of Fort McMurray has undergone significant growth in the past five years. The rapid growth is expected to continue, reaching 75,000 persons or more by 2015, from a present day population of 50,000 (est. for 2004). The urban service area for the oilsands has a shadow population estimated at 4500 persons within the urban limits (living in illegal suites or campgrounds, or as permanent hotel residents) and an additional 10,000 persons living and working in camps north and south of the City. The population growth is placing extreme pressure on all municipal and provincial infrastructure, including roads, which are operating far beyond their original design capacity. (2)

This paper concerns the intersection of Highway 63 (the main and only provincial highway access through the City to the oilsands in the north) and King Street (a major arterial serving the Waterways community, the local college, a secondary school, and the downtown commercial area.) This intersection was locally considered a "death trap." In 2003 a new interchange was opened, replacing the at-grade intersection. The new interchange is unique in that it contains a modern roundabout instead of the diamond or trumpet designs that one might expect. This unique design best fits the situation, and has many potential applications across this country. The authors believe that this is the first application of a modern roundabout to an interchange in Canada. This paper outlines the process that led to the implementation of this unique application of the modern roundabout.

Highway 63 North

In the mid 1960s the great Canadian Oil Sands began production of synthetic crude from their plant north of the Town of Fort McMurray. The Town of just over 3,000 residents began to grow and reached 8,500 by the early 1970s. The Town was virtually isolated with access to the outside only by logging road, rail or air. Although the synthetic crude was shipped south by pipeline, access for people, construction materials and consumer goods was restricted to rail. In the 1970s, Syncrude Canada began construction of their first oil extraction plant and the population continued to grow, reaching 20,000 persons by the early 1980s. (2)

In the 1970s, Alberta Transportation completed Highway 63 through Fort McMurray, vastly improving surface access through the Town to the oilsands plants to the north. At that time, the intersection of King Street and Highway 63 was at the town limits. Traffic volumes were low and the intersection operated satisfactorily.

The Town grew into a City and the population increased to almost 30,000 persons by 1990. During the 1980s, Highway 63 was twinned through the Municipality, yet the intersection with King Street, now in the middle of the urban area, remained at-grade. The City of Fort McMurray, which operated and maintained the Highway through Fort McMurray, proceeded with a functional analysis of the intersection and concluded in a 1991 study that the intersection should be converted to an interchange.

In 1995, the Regional Municipality of Wood Buffalo was formed. Alberta Infrastructure (now Alberta Transportation) and the Regional Municipality jointly commissioned a functional planning study on the entire length of Highway 63 within the Urban Service Area of Fort McMurray. This was completed in early 2000, with access recommendations for Highway 63 through Fort McMurray. The interchange of Highway 63 and King Street was deemed the highest priority. Council accepted the functional plan for the interchange. In April of 2000, Alberta Transportation assumed responsibility for Highway 63 in the Urban Service Area. Alberta Transportation then proceeded with a request for proposal for functional planning review, design, and construction of the “King Street interchange.”

Reid Crowther and Partners [now Earth Tech (Canada) Inc.] was retained by Alberta Transportation to proceed with this project.

The Highway 63 / King Street Intersection

Figure 1 locates the intersection on Highway 63 within the Urban Service Area. The intersection

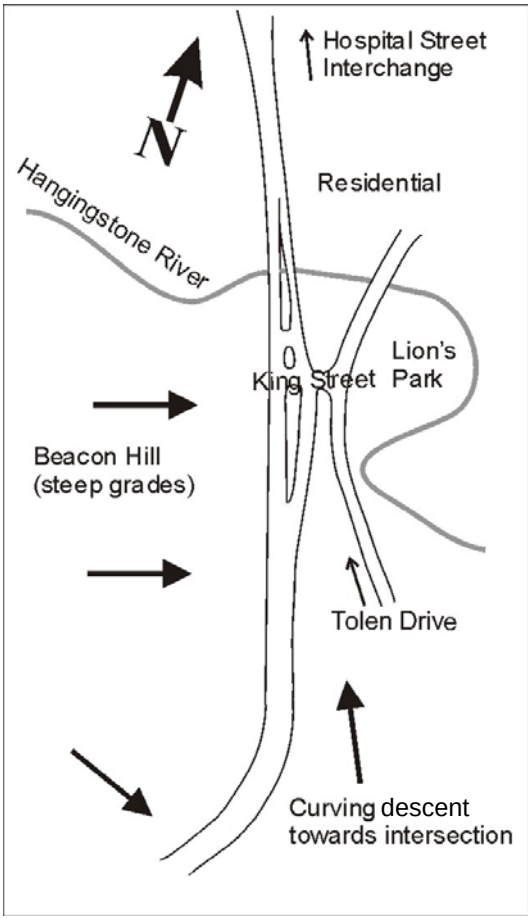

Figure 1: Study Area Features

was at the bottom of Beacon Hill, south of the Hangingstone River and approximately 400 metres south of the Hospital Street interchange. Drivers heading north, towards Hospital Street, faced a curving roadway down a significant grade just a few hundred metres before coming to the King Street intersection and its nearby link to Tolen Drive. The intersection provides direct access to two schools, including a community college, several businesses, and the southeast end of the growing commercial area in the Lower Townsite.

During the peak period, long lineups occurred on King Street and on Tolen Drive for those drivers attempting to access Highway 63. The lineups also created delays for drivers accessing King Street from Tolen Drive and vice-versa. Lineups on southbound Highway 63 accessing King Street protruded into the left-hand driving lane. The intersection operated at a level-of-service "F" during these periods.

The layout of the Highway 63/King Street intersection as it was in 2000 is shown in Figure 2:

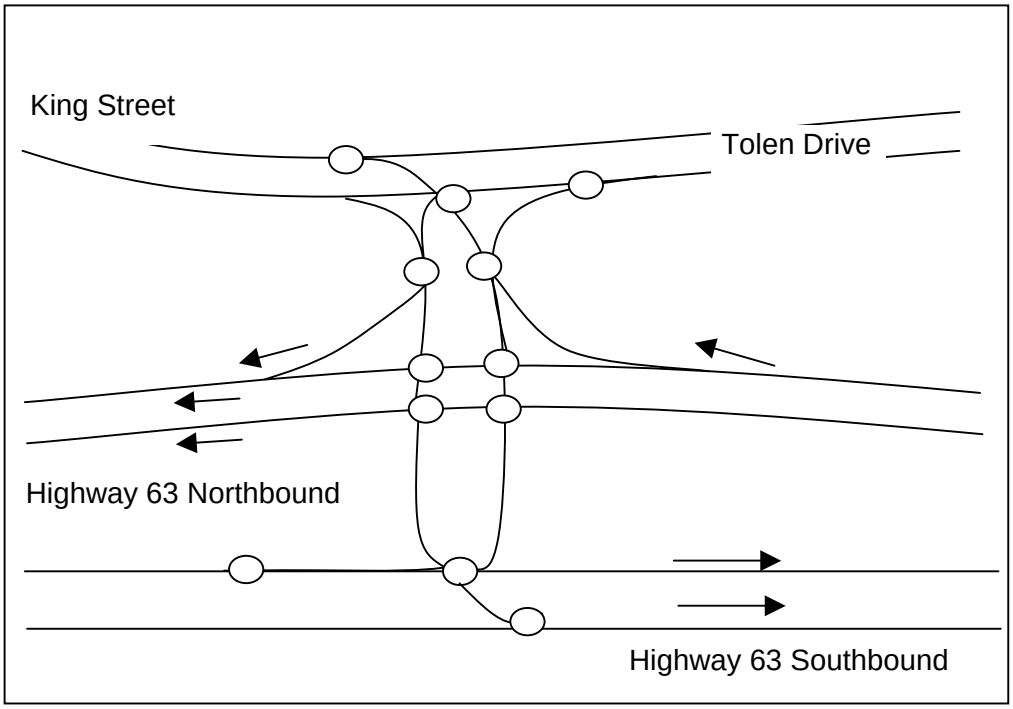

Figure 2: Intersection Details

The layout creates 12 separate conflict points (i.e. points where vehicles must merge with or cross the path of other vehicles.). As traffic volumes increase, the potential for vehicle collisions at these conflict points also increases. The greater the number of conflict points, the greater the likelihood of property damage, personal injury and even death.

Accident History

The accident history of the King Street intersection was unacceptable. From 1994 to 1998, there were a total of two traffic deaths, 48 personal injury accidents, and 17 collisions reporting property damage in excess of $1000. The accident statistics are summarized in Table 1. The alignment made the intersection one of the most "accident prone" in the City of Fort McMurray. It should be noted that these statistics do not include accidents at King Street and Tolen Drive (i.e. those not directly involving the highway).

Direction	Fatal (# deaths)	Injury (#injuries)	Property Damage	Total
Northbound	1(1)	1(3)	4	**6**
Southbound	0	0	1	**1**
Eastbound	1(1)	11(28)	9	**21**
Westbound	0	9(17)	3	**12**
Total	**2(2)**	**21(48)**	**17**	**40**

Table 1: Traffic Accident Statistics, Highway 63 and King Street Intersection (1994 – 1998) (3)

As traffic volumes increased, more accidents of all types could have been expected. The design and accident history were major factors dictating the need to move to an interchange at Highway 63 and King Street.

Traffic Volumes: Year 2000 and Projected

In 2000, significant traffic volumes through the intersection merging or crossing Highway 63 were creating an operating level-of-service "F" at the intersection for short periods during the day. The northbound peak period on Highway 63 north was 1000 vehicles per hour (vph) with 350 vehicles crossing northbound traffic and 189 vehicles merging with northbound traffic. Projections noted that by the time the urban service population exceeds 49,000 persons (exceeded in 2003), some 1350 vph are expected northbound in the peak period with crossing traffic reaching 450 vph. (Note: The interchange was under construction at that time and these volumes are forecast, not observed). (1) Figure 3 illustrates some of the key movements in these volumes.

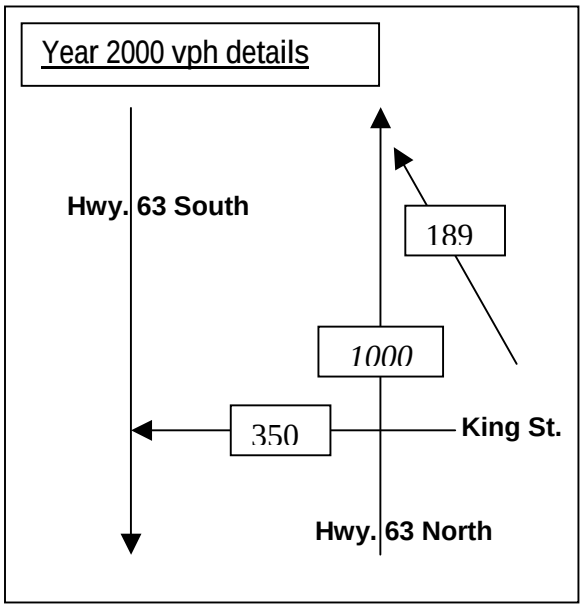

Figure 3: Intersection Volumes (1)

When the population reaches 67,000 (2012), anticipated peak hour volumes will be 1910 vph northbound on Highway 63 and 490 vehicles crossing traffic on the northbound lane of Highway 63.

In general, the more times the conflict points (see Figure 2) are crossed, the greater the likelihood of a vehicular accident and the greater the probability of property damage, personal injury and even death.

Given this history, Alberta Transportation proceeded with the functional design of an interchange to improve this very busy and dangerous intersection.

Functional Design Study: 1998 - 2000

A functional design study was carried out by ISL Engineering of Fort McMurray for the entire length of Highway 63 within the Urban Service Area. Alberta Transportation and the Regional Municipality of Wood Buffalo jointly sponsored this study, which included the functional design of an interchange at King Street and Highway 63.

In 2000, ISL updated the functional plan for the interchange, incorporating input from the Regional Municipality of Wood Buffalo, Alberta Transportation, and the public. This functional design included the following characteristics:

- All directional traffic accommodation
- Tight diamond design
- Highway 63 over King Street

After being awarded the functional planning, detailed design and construction supervision contract for the interchange, the Earth Tech team began by reviewing ISL's proposed alternatives. The team developed eight additional alternatives, based in varying levels on ISL's designs. Details of the two most promising alternatives – Highway 63 over King Street and a diamond with Highway 63 under King Street – are listed on the next page, in Table 2:

	"Highway Over"	**"King Street Over"**
Merge distance to Hospital Street interchange	265 m	430 m (acceptable by highway standards)
"Footprint" compared to ISL design	Same location	Shifted south
Costs	$25-30 Million	$20-25 Million
Parkland requirement	None	Approx. 10 acres

Table 2: Comparison of Original "Best" Alternatives

This comparison showed that neither alternative was acceptable. There were either problems with weave distance and structure costs, or there was a considerable impact on the existing parkland space. In addition, the lower cost option was unlikely to operate at higher than a "C" or "D" level-of-service for very long.

"Thinking Outside the Box"

After evaluating these alternatives, the team realized that an entirely new design was necessary. Each of the problem areas associated with the previous diamond and trumpet designs had to be addressed individually, and from these ideas, a new design would be created.

The project team focused on improving weaving distances by looking for ways to draw the King Street/Tolen Drive intersection further away from the river crossing. Ideally, the weave could be completely accommodated to the south of the river – this would reduce the need for an additional structure across the river to accommodate a weaving lane, and would therefore keep this lane further away from the residential area directly north of the river. One way to draw the weave further south was to increase its elevation in the vicinity of the park. The key with a new design, however, was to ensure that the elevation increase did not result in the loss of parkland associated with earlier plans.

It had become clear to the team that the first task of the new interchange design was not the interchange itself, but the *intersection* design for King Street and Tolen Drive. Once the intersection was functional, its incorporation into the interchange could be addressed.

The team reviewed a variety of intersection designs and revisited their original trumpet design. The key was to find an intersection with noted success when incorporated into an interchange like this. The modern roundabout concept was first brought forward because team members had noted that the introduction of roundabouts at major highway intersections had been successful in both Europe and the United States, and that an increasing number were being constructed in the U.S. at the time. The modern roundabout has been designed to accommodate B-train movements (a factor with Highway 63 traffic), and short additions could be incorporated to allow for oversize loads moving on Highway 63. Initial concept work, including review of a new document produced by the U.S. Federal Highway Administration, revealed that the entrance leg capacities of roundabouts could be greater than projected volumes at the 67,000 population level, and could reduce collisions in terms of both number and severity. (4)

One report, in particular, was very helpful for the team as they considered the feasibility of the roundabout, and the likelihood it would reduce collision statistics:

> The present study evaluated changes in motor vehicle crashes following conversion of 24 intersections from stop sign and traffic signal control to modern roundabouts. The settings, located in 8 states, were a mix of urban, suburban, and rural environments. A before-and-after study was conducted using the empirical Bayes approach, which accounts for regression to the mean. Overall, the empirical Bayes procedure estimated highly significant reductions of 39 percent for all crash severities combined and 76 percent for all injury crashes. Reductions in the numbers of fatal and incapacitating injury crashes were estimated to be about 90 percent. Overall, results are consistent with numerous international studies and suggest that roundabout installations should be strongly promoted as an effective safety treatment for intersections. (5)

As winter conditions and oversized loads are some of the most obvious concerns for any interchange, let alone one as unique to Alberta as the proposed roundabout, the team sought examples from similar climates and traffic mixes. A successful recent roundabout installation in Vale, Colorado, provided the support the team needed, as Colorado winter conditions were certainly comparable, and since operations at this new interchange seemed favorable. (6)

Based on these initial findings, the team developed a concept specific to the Highway 63/ King Street scenario using the detailed design criteria developed by the Federal Highway Administration document. It became apparent early in the design process that a unique retaining wall system would be necessary to accommodate the elevated roundabout, with its improved weaving distance. This retaining wall would also provide the benefit of a very small footprint within the adjacent parklands, and be an aesthetic improvement to the existing roadway passage alongside the park. A version of the proposed interchange design is shown in Figure 4, on the next page. Although functional, the team had some concerns about how this radical design would “go over” with drivers, who have expressed concern and reluctance about “traditional” traffic circle designs in other applications.

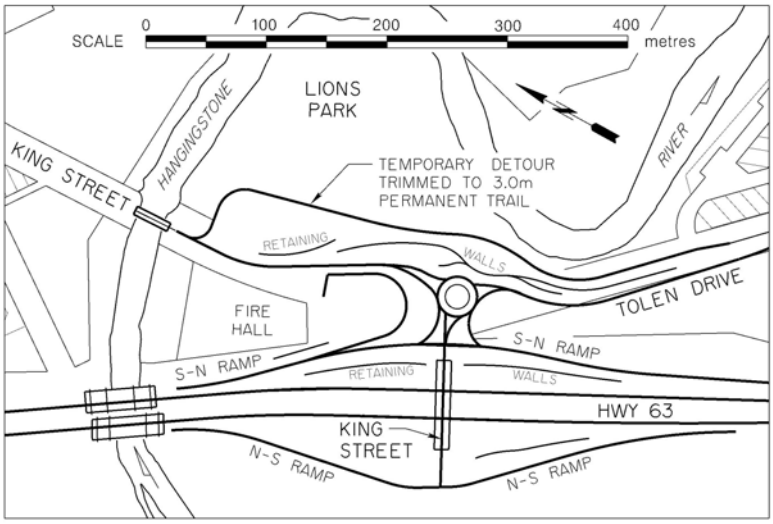

Figure 4: The Roundabout Interchange Design

Approvals

Following detailed reviews and preliminary approvals from Alberta Transportation, the team and client brought the roundabout design to the Municipality's Transportation Standing Committee before forwarding it for a full Council review. The team used the Vale roundabout video as part of their presentation to the committee, and supplemented this with preliminary Corsim analyses. A comparison of the three alternatives, similar to that in Table 3, was provided to the Committee:

	"Highway Over"	**"King Street Over"**	**Roundabout Design**
Structures Required	New bridge over river (for weaving traffic)	New bridge structure over river	Extension of *existing* river bridges
	Overpass to accommodate the highway	Overpass to accommodate King Street	Overpass and retaining walls to accommodate King Street and roundabout
Other Considerations	Noise concerns associated with an elevated highway	Very difficult grades	Roundabout capacity of 2600 vph will meet 67,000 population AND can be upgraded
		Capacity concerns, especially for future volumes/growth	Cost of $22M is within range of the other alternatives
			Roundabout offers continual traffic flow and boasts strong safety statistics
			Park lands are spared

Table 3: Final Comparison of the Three Alternatives

Based on the success of the approach used with Council and its Standing Committee, Corsim traffic simulation software was also the first tool chosen for use at the public open houses. It allowed the public to compare scenarios: traffic-light controlled, versus yield-control. The long queues forming on the traffic-light version were easily distinguishable for all viewers, and were almost unanimously viewed as inferior to the two or three car maximum "pauses" at the entrances to the roundabout. This modeling also illustrated that the pauses were much shorter in duration than the full stops at the traffic lights, so that even those cars proceeding through the lights were not gaining a significant amount of time over those slowing down at the yield-controlled entrance points on the roundabout.

Another important visual aid was a computer animation featuring cars and trucks moving through the interchange. Comment forms received from the public praised the effectiveness of both tools in truly "explaining" the need for a roundabout, and showing that it would be an effective traffic control device. These tools were supplemented by static displays and commentary from team members, who were on hand throughout the seven hour event. The length of the event is worth noting: as Fort McMurray has a large shift-work population, it was important to offer as wide a range of times for drop-in as possible. These extended hours also received support in the comment forms.

Final Roundabout & Interchange Designs

Based on the feedback received, on directions from council and client, and on negotiations with affected landowners – including the fire department and Lion's Club park operators – the final design of roundabout, ramps, and other features of the interchange were set. These details included:

- Roundabout to have a 24 metre radius, with a 4 metre apron for trucks
- Roundabout revised to two lane ultimate stage, single lane initial stage
- All entries designed with lower radius, exits with higher radius

Construction & Operations to Date

Construction began in the summer of 2001, and continued through the winter during river freeze-up. The summer of 2002 was colder and wetter than expected, and this slowed progress to a point that the opening was held off until work could proceed the next spring and summer. Traffic accommodation during construction was a key consideration of all parties, and as such, was handled through careful coordination between the RCMP, Municipality staff, construction contractors, and the project team's construction supervisor. The interchange was opened to traffic on July 4, 2003, in time for the World's Seniors Games, a prestigious event being hosted by the residents of Fort McMurray.

As the interchange has been operational for less than one full year, formal traffic accident statistics are unavailable. Informal observation and feedback from stakeholders has confirmed, however, that operations have improved considerably, and driver confusion has apparently not been a factor. The roundabout has become a local landmark, and is a regular topic of conversation for both visitors and residents.

Conclusions

The incorporation of a modern roundabout into the Highway 63/King Street interchange was the key reason for the success of this design. Traffic flow has improved, it appears that collisions have been reduced, and Lion's Park was not sacrificed to accommodate traffic. Although public perception of the roundabout style of intersection was an important and well-documented concern for the parties involved with the project, careful design and promotional efforts proved an effective means of diffusing concerns and delivering improved operations.

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