



## **THE TURBO ROUNDABOUT A FIRST IN NORTH AMERICA**

Tim Murphy, ASCT, MBA, PMP, Eng.L., P.L.(Eng.)  
Senior Project Manager, Parsons Inc.

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**PARSONS**

## ABSTRACT

The Victoria International Airport wished to expand their surface parking lots and relocate a main roadway at the airport. The project included a new intersection which was planned to have a roundabout. A previous planning study had recommended either a single lane or double lane roundabout be implemented at the intersection. A Value Analysis was undertaken with the Client to analyze the required functions at the intersection, develop alternatives, assess the alternatives, and discern a preference. From this analysis, a new roundabout technology developed in the Netherlands, the “Turbo Roundabout” was selected as the preferred roundabout design for this project. Turbo roundabouts are multi-lane roundabouts with spiral road markings and separated circulating lanes. They perform much better with respect to capacity and safety than standard multi-lane roundabouts, while not needing any additional space. In 2007 over 70 turbo roundabouts were in operation in the Netherlands. The typical layout of a turbo roundabout is shown in the *Figure 1* below.



Source: DHV

**Figure 1 – Basic Turbo Roundabout**

This paper will describe how the Turbo roundabout technology developed in the Netherlands was adapted and applied to build the first Turbo roundabout in North America, at the Victoria International Airport.

## ROUNDAABOUT CONCEPTS

The new intersection at the Victoria International Airport is estimated to have a service life of about 20 years. As the airport continues to expand to accommodate growth, the exit road from the airport terminal is planned to be relocated and this intersection would be decommissioned with the land used for other purposes. A previous transportation planning study revealed that a single lane roundabout would have sufficient capacity to meet forecast traffic demands for a 15 year horizon period, but by the 20 year horizon period the roundabout would need to be a two lane roundabout to accommodate the demand. The Airport desired a roundabout for this intersection, however as the project advanced to the design stage, the dilemma was to either:

- Implement a single lane roundabout now, knowing it will not have sufficient capacity for the expected 20 service life of the intersection; or,
- To build a two lane roundabout now, knowing it would have excessive capacity in near to midterm period.

The design team proposed to examine other roundabout design technologies that offer greater capacity than a single lane roundabout but were less costly than a double lane roundabout. A scan of available roundabout technologies lead to the Turbo roundabout technology developed in the Netherlands as the most promising candidate for this project.

## TURBO ROUNDABOUT TECHNOLOGY

The Turbo roundabout was invented by Dr. Bertus Fortuijn, a Senior Lecturer at Delft University of Technology, in 1996 to address the poor safety performance of multi-lane roundabouts in the Netherlands. In 2009, the DHV Group in the Netherlands (a company partly owned by Delcan Corporation, now Parsons Inc.) partnered with the Ministry of Transport, CROW, Province of Zuid-Holland, and Royal Haskoning to prepare a design guide for roundabouts. The design guide included the planning and design of Turbo roundabouts. It was through this design guide assignment that the Turbo roundabout first came to our attention. Graphics of the basic Turbo roundabout are shown in **Figures 1 and 2**.



Source: DHV

**Figure 2 – Basic Turbo Roundabout Perspective View**

Some of the key design features of the Turbo roundabout include:

- At least one entry has a second lane inserted in the central island;
- Spiral road markings guide traffic from inside to outside, avoiding weaving and reducing conflicts in the roundabout;
- Mountable-raised lane dividers control traffic path and speed by keeping vehicles in their lane and by using a small roundabout diameter; and
- Traffic must choose the appropriate lane for the desired turning movement prior to entering the roundabout.

These features are visible in **Figure 2**.

The start of the raised mountable lane divider has a small triangular island called the “Frog”. A picture of the Frog is shown in **Figure 3**. **Figure 4** shows the raised mountable divider on a two-lane exit from a Turbo roundabout. Note that vehicles in the outside circulatory lane have no choice but to exit the roundabout due to the raised lane divider. Traffic in the inside circulatory lane has the choice to continue to circle the roundabout or exit the roundabout at this point. Weaving from the outside lane to the inside lane has been eliminated at this exit from the roundabout.



Source: DHV

**Figure 3 – Beginning of Raised Lane Divider (Frog)**



Source: DHV

**Figure 4 – Raised Lane Divider**



Source: DHV

**Figure 5 – Separated Cyclist / Pedestrian Crossing**

Many Turbo roundabouts in the Netherlands have two – stage pedestrian and cyclist crossings on the approaches to the roundabout, as shown in **Figure 5**. Note that in this two – stage crossing example, pedestrians are segregated from cyclists, and the cyclists separated by direction.

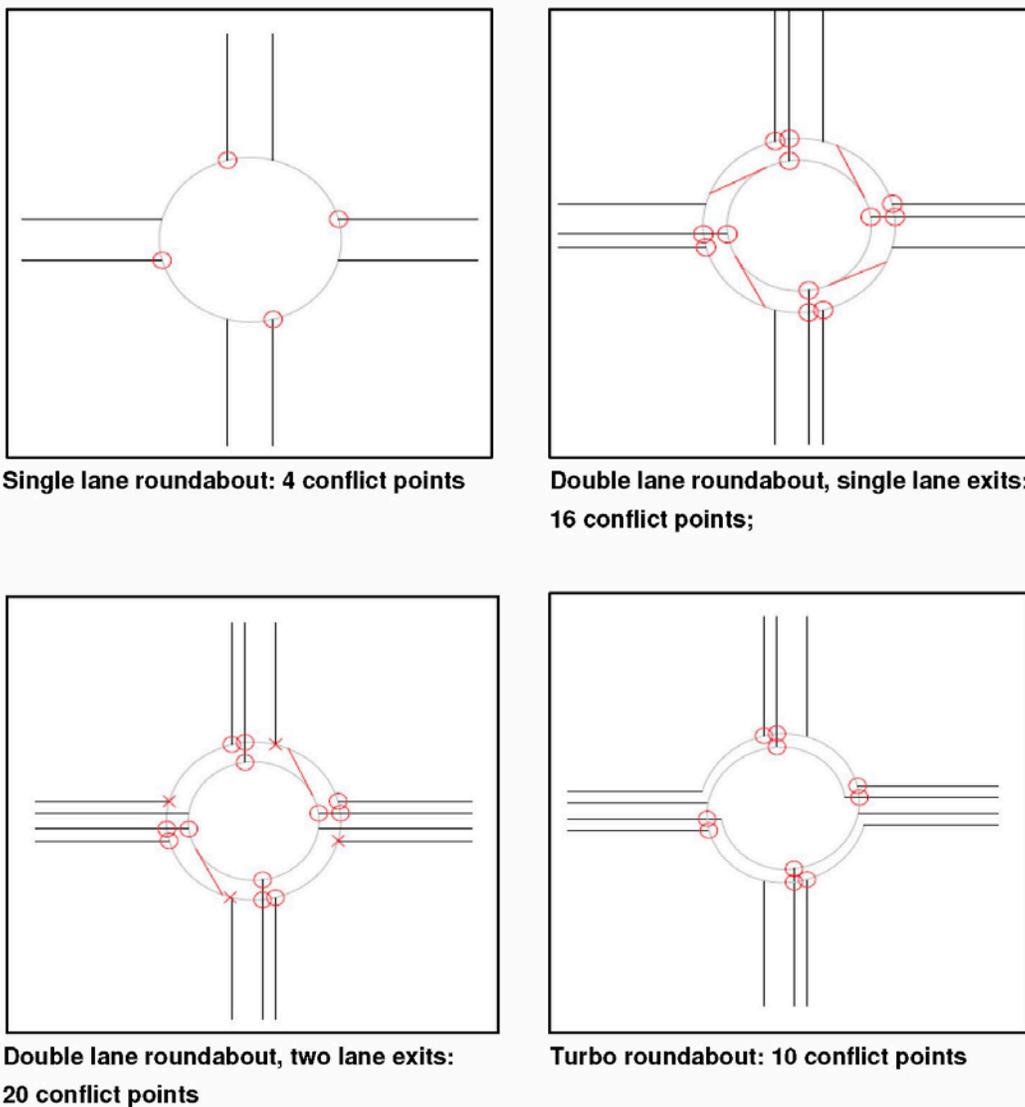
In terms of roundabout capacity, the basic Turbo roundabout was observed to have the same practical capacity as a multi-lane roundabout with two entry and two exit lanes, in the Netherlands as shown in **Table 1**. Note, that the Practical or observed capacities were found to be lower than the Theoretical capacities for roundabouts in the Netherlands. This is similar to observations in Canada.

**Table 1 – Roundabout Capacity Comparison**

Type of Roundabout	Capacity	
	Practical (pcu/h)	Theoretical (pcu/h)
Single Lane Roundabout	2,000	2,700
Multi-lane Roundabout with single entry and exit lanes	2,200	3,600
Multi-lane Roundabout with two entry lanes and single exit lane	3,000	3,600
Multi-lane Roundabout with two entry lanes and exit lanes	3,500	4,000
Basic Turbo Roundabout	3,500	3,800

Source: DHV

The primary objective of the Turbo roundabout design is to improve the safety performance of multi-lane roundabouts by reducing the number of conflict points. As shown in **Figure 6**, the basic Turbo roundabout only has 10 conflict points, due to the elimination of weaving in the roundabout and lane changing at the roundabout exits. The typical double lane roundabout with two entry lanes and two exit lanes has 20 conflict points.



Source: DHV

**Figure 6 – Roundabout Conflict Point Comparison**

The performance of the Turbo roundabout has been so successful in the Netherlands that new double lane roundabouts are no longer being implemented, and existing double lane roundabouts are being reconstructed to be Turbo roundabouts.

### TECHNOLOGY ADAPTION FOR A CANADIAN APPLICATION

Our initial exposure to the Turbo roundabout was the recently developed roundabout design guide for the Netherlands. However, when we examined existing Turbo roundabouts in the Netherlands, we saw that most of the roundabouts had a curvilinear entry into the central island as opposed to the 90 degree notch that was shown in the design guide. **Figure 7** is an example of the curvilinear design for the majority of Turbo roundabouts.



Source: DHV

**Figure 7 – Turbo Roundabout in Reeuwijk, Netherlands**

We also conducted an environmental scan to determine if other countries had implemented Turbo roundabouts. The scan revealed that Slovenia and Germany had implemented Turbo roundabouts but with some adaptations. Both Slovenia and Germany used the curvilinear design for the entry into the central island. Slovenia also used triangular splitter islands on the non-Turbo treatment approaches, and the raised mountable dividers did not have a “Frog” at the start of the divider. Germany did not use raised dividers to separate the two circulatory lanes. The German Turbo roundabouts also had guide lines to direct entering traffic into the appropriate circulatory lane.

For adapting the Turbo roundabout technology for the application at the Victoria International Airport, the following design elements were selected:

- The “old” design standard for the beginning of the left lane in the central island with the curvilinear entry instead of the right angle entry was selected;
- Turning lane guide lines provided for two-lane entry into the Turbo Roundabout (adaption from Germany);
- Angled splitter islands provided for single lane entry into the Roundabout (adaption from Slovenia);
- Design used TAC design vehicles, instead of the European design vehicles used in the Netherlands; and
- The Circulatory lanes used a flat median due to winter road maintenance concerns and the Airport using the same snow plow vehicles designed for clearing runways, which have very wide plow blades, to clear snow on the airport roads.

## PROJECT DESIGN

Applying the selected design elements to the roundabout at the intersection of Electra Boulevard and Willingdon Road within the Victoria International Airport resulted in the design shown in **Figure 8**. The Turbo treatment was applied to the two-lane one-way Electra Boulevard leg of the intersection. Triangular splitter islands were included on the Willingdon Road approaches. Two circulatory lanes extend from the southbound entrance to the eastbound exit of the roundabout.

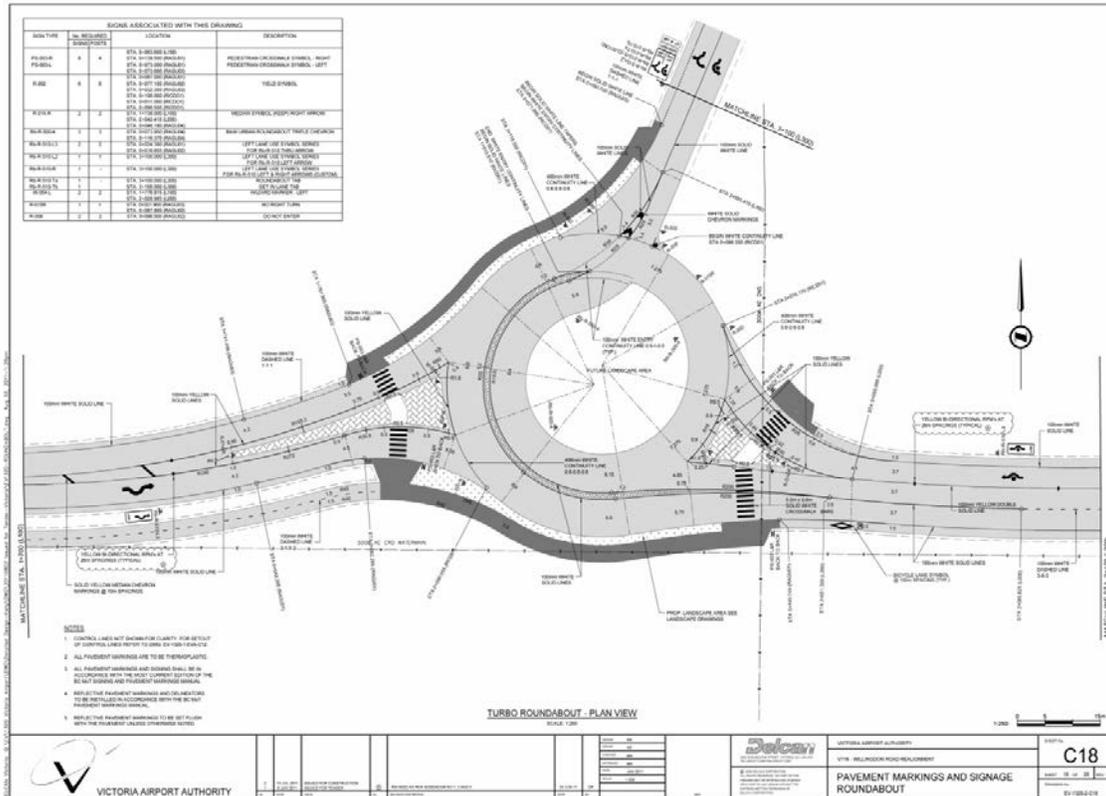


Figure 8 – Knee Turbo Roundabout Design for Victoria International Airport

The beginning of the flat lane divider did not include a “Frog” as shown in **Figure 9**. The lane divider is 1.2 metres wide from white line to white line with a textured pavement treatment as shown in **Figure 10**.



*Figure 9 – Beginning of Lane Divider*



*Figure 10 – Lane Divider*

On opening day of the roundabout, an issue with some motorists attempting to turn left and travel in the roundabout in a clockwise direction was observed. In each of these instances, the motorist was an elderly male who either was not aware of roundabout symbols on signs and on the road, or had deteriorated vision and was not able to discern the symbols correctly. The Victoria area is a preferred location for retirement in B.C., therefore there is a high proportion of seniors in the area. To address this issue, a small diverter island with a no left turn sign was added to the Turbo treatment approach, as shown in **Figures 11** and **12**. This provided enough of a visual glue for motorists to turn to the right on entering the roundabout and there were no further instances of incorrect turns on this approach.



**Figure 11 – Small Island Diverter**



*Figure 12 – Small Island Diverter Rear-view*

## RELATIVE SAFETY PERFORMANCE COMPARISON

The Turbo roundabout was constructed and opened to traffic in 2010. Now that it has been in operation for three years, it would be appropriate to compare the safety performance of the roundabout with other multi-lane roundabouts in British Columbia (B.C.). There are 11 multi-lane roundabouts in B.C. that have been in operation for at least three years. Four of these roundabouts are located at two interchanges the McTavish interchange and the McCallum Road and Highway 1 interchange. The location, jurisdiction, and brief description of multi-lane roundabouts in B.C., is shown in **Table 2**.

**Table 2 – Multi-Lane Roundabouts in BC**

Location	Jurisdiction	Description
Marshall Road & Clearbrook Road	Abbotsford	Spiral roundabout ( 3 - 2 lane exits, 2 right turn bypass lanes)
Evans Road & Yale Road	Chilliwack	2 lane roundabout ( 4 - 2 lane entries, 4 - 2 lanes exists)
McCallum Road & Highway 1 Interchange	Abbotsford	2 Spiral roundabouts (both with 3 - 2 lane exits)
8th Avenue & Highway 99	Surrey	2 lane roundabout ( 2 - 2 lane entries, 2 - 2 lane exits)
Mount Lehman Road & South Fraser Way	Abbotsford	2 lane roundabout (3 legs, 2 - 2 lane entries, 2 - 2 lane exits)
McTavish Interchange	Sydney	2 Spiral roundabouts (2 lane entries, 2 lane exits)
16th Avenue & Westbrook Mall	UBC	Spiral roundabout ( 1 lane exits, 2 right turn bypass lanes)
Commercial Way & Discovery Way	Squamish	2 lane roundabout (2 lane entries, 2 lane exits)
Willingdon Road & Electra Boulevard	Victoria Airport	Turbo roundabout (knee, 3 legs, 1 - 2 lane entry, 1 - 2 lane exit)

Collision data for these roundabouts was obtained from the ICBC collision claims data website for the period 2011 – 2013 (three years). In total there were 711 records for the multi-lane roundabouts in B.C. during this period. **Table 3** summarizes the frequency of collisions by year by location. On average, there have been about 21 collisions per year at multi-lane roundabouts in B.C. However, this ranged from as high as 44 collisions per year at the Marshall Road and Clearbrook Road roundabout, to as low as 0.3 collisions per year at the Turbo roundabout. Note that for interchanges with two multi-lane roundabouts, the crash data did not discern specifically which roundabout the crash occurred, therefore the crashes were assigned equally to both roundabouts. In terms of crash frequency, it appears the Turbo roundabout experienced a much better road safety performance than the other multi-lane roundabouts in B.C.



**Table 3 – Roundabout Safety Performance Comparison**

Location	Crashes			Total Crashes	Crashes / Year / Roundabout	Estimated Traffic		Crash Rate (/MEV)
	2011	2012	2013			AWDT	Yearly Traffic	
Marshall Road & Clearbrook Road	38	47	48	133	44.3	25000	8750000	5.07
Evans Road & Yale Road	33	35	37	105	35.0	24000	8400000	4.17
McCallum Road & Highway 1 Interchange	95	50	45	190	31.7	28000	9800000	3.23
8th Avenue & Highway 99	26	19	38	83	27.7	18000	6300000	4.39
Mount Lehman Road & South Fraser Way	17	16	25	58	19.3	30000	10500000	1.84
McTavish Interchange	41	34	33	108	18.0	26000	9100000	1.98
16th Avenue & Westbrook Mall	16	8	3	27	9.0	15000	5250000	1.71
Commercial Way & Discovery Way	0	4	2	6	2.0	1000	350000	5.71
Willingdon Road & Electra Boulevard	0	0	1	1	0.3	4300	1505000	0.22

To normalize the effect of exposure on the frequency of crashes, i.e. more crashes occur where there is more traffic. The volume of traffic being processed at each roundabout was estimated at a high level to facilitate a crash rate analysis. Traffic counts were not available at many of the locations. For these locations, peak hour counts were expanded to represent daily traffic volumes or traffic volumes were inferred from nearby traffic counts. Based on these traffic estimates, the crash rate per million entering vehicles for the multi-lane roundabouts was calculated and is shown in **Table 3**. In terms of crash rate, it appears the Turbo roundabout also experienced a much better road safety performance than the other multi-lane roundabouts in B.C.



## CONCLUSIONS

This project implemented the first Turbo roundabout in North America. The Turbo roundabout has performed well at this location and resulted in the following conclusions:

- The Turbo roundabout has less conflict points, and has experienced a better safety performance than all the other multi-lane roundabouts in B.C.;
- With some adaption the Turbo roundabout can be successfully implemented in Canada; and
- Subsequent Turbo roundabout designs in Canada and North America should consider mountable-raised lane dividers, possibly with flexible signing and delineation, to maximize the potential benefits of reduced conflicts.

## REFERENCES

DHV, “Roundabouts – Application and Design, A Practical Manual”, File No. B5381-01.001, Registration Number: VB/SE2008.0772, June 2009.