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Turbo Roundabout Design? Redesign of Park City's 14 Year Old Deer Valley Roundabout

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Abstract:
Turbo roundabouts have proven to be very successful to improve intersection traffic safety and capacity when compared to traditional two-lane roundabouts. This paper introduces the benefits of turbo roundabouts as experienced in the Netherlands as well as some of the features of turbo roundabouts that have been incorporated into recent roundabout projects in the USA.

1. Turbo Roundabouts in the Netherlands

The turbo roundabout is an innovative arrangement of a two-lane roundabout that has revolutionized roundabout design in the Netherlands since 1998. Entering and exiting a typical two-lane roundabout can be complicated for some drivers, which may lead to accidents due to lane changing inside the roundabout. The turbo roundabout eliminates some of the most severe conflict points on a roundabout and reduces the need to change lanes. The capacity of a turbo roundabout is about 25 – 35% higher than a standard two-lane roundabout. (1) The higher capacity is mainly due to the improved utilization of the inner lanes of the roundabout.

Essential Features

The most important feature of the turbo roundabout is the spiral lane marking to eliminate the necessity of weaving or changing lanes. This results in both an increase in safety as well as an increase in the capacity of the roundabout. The turbo roundabout does not have two lanes throughout the whole roundabout, but only over the sections where two lanes are required. At least one of the exits should have two lanes, but in certain instances it may be necessary for all exits. (3) Figure 1 shows a typical turbo roundabout in the Netherlands at the intersection of a major street and minor street.

Figure 1. Typical Turbo Roundabout in the Netherlands (Brielle, NL Google Maps)

When compared to a typical two-lane roundabout a turbo roundabout reduces the number of potential conflict points from 16 to 10. This is mainly the result of the elimination of the weaving conflicts (a reduction of 4 conflicts) in the roundabout. A further benefit is that traffic in the main direction only has to consider crossing one lane before entering the roundabout (a reduction of 2 conflicts). (3)

Since weaving in the roundabout is no longer necessary, the lane divider can be slightly elevated (Figures 2 and 3). Such a mountable lane divider induces traffic to keep its own lane, and this helps to prevent sideswipe collisions that can occur not only upon entering the roundabout, but also when exiting. Heavy and oversized vehicles can traverse the lane dividers if necessary, as shown in Figure 4. The raised lane divider in the Deer Valley, Utah roundabout was inspired by the design details of the turbo roundabout developed in the Netherlands.

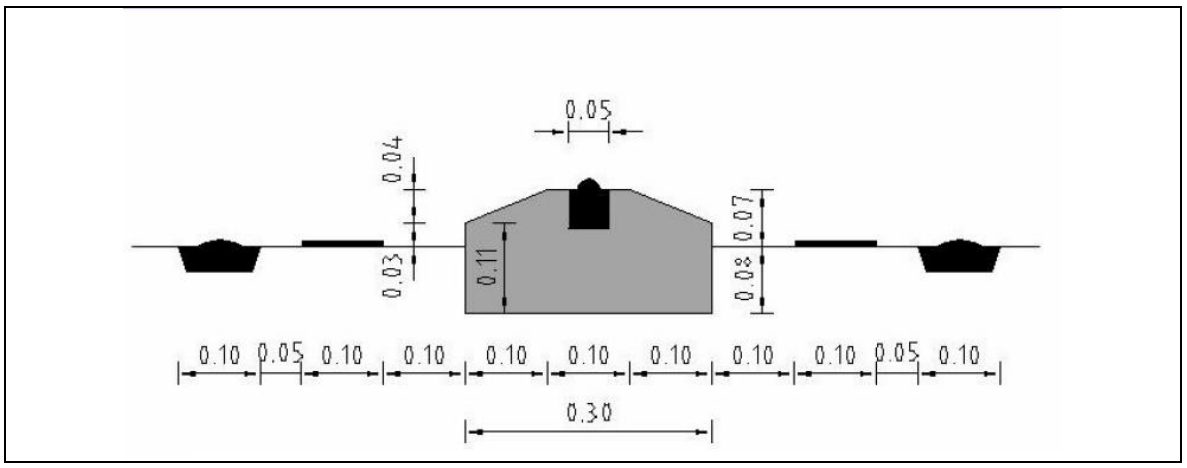

Figure 2. Turbo Roundabout Raised Lane Divider Detail in Netherlands (Fortuijn)

Figure 3. Turbo Roundabout Raised Lane Divider in the Netherlands (Fortuijn)

Figure 4. Turbo Roundabout Raised Lane Divider in the Netherlands (Fortuijn)

As a result of the lane dividers, drivers need to choose the correct lane before they enter the roundabout. Drivers should be assisted by clear signposting and lane marking. The quick-scan model shows that the capacity of a turbo roundabout is about 25% to 35% higher than the capacity of a two lane roundabout, depending on the balance of the traffic volumes on the approaches. The main reason for the higher capacity of the turbo roundabout is the reduction of conflict points for traffic entering and exiting the roundabout (3).

On a typical turbo roundabout there are 10 conflict points for vehicles, while on a two-lane roundabout there are 16. This represents 60% more conflict points, including four weaving conflicts and two exiting conflicts, which amount to a higher accident risk for a two-lane roundabout (4). A turbo roundabout is therefore a significantly safer option. Unfortunately, there is very little quantitative safety data available for accurate comparison of the two options. See Figure 5.

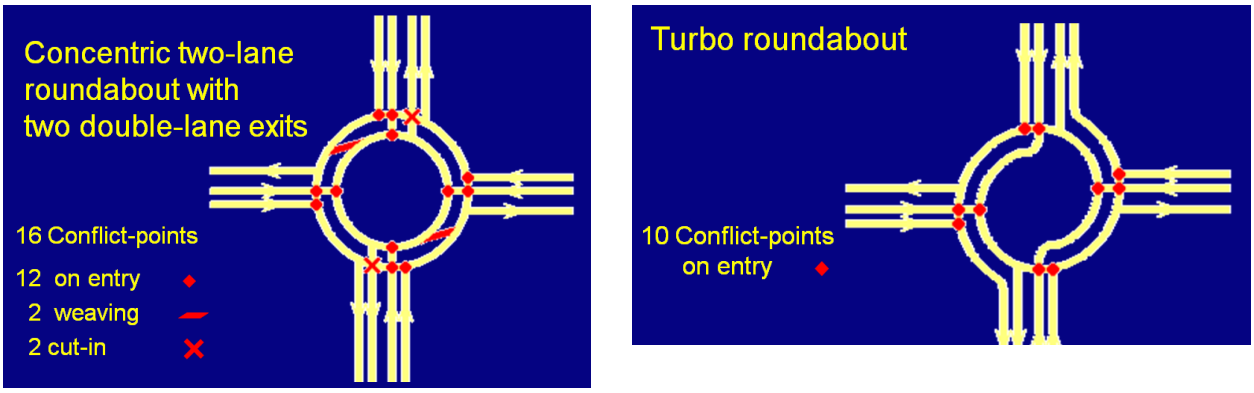

Figure 5. Conflict Points Comparison: Two-lane Roundabout vs. Turbo Roundabout (Fortuijn)

Research from the Netherlands does make a comparison between turbo roundabouts and traffic signals or yield control intersections. It shows that a 70% reduction of accidents resulting in serious injuries can be expected when introducing a turbo roundabout at such an intersection

(4). The same applies to the introduction of a one-lane roundabout, however this would result in a lower intersection capacity.

Reduced Right-of-Way and Second Lane Inserted in Center Island
Turbo roundabouts require less right-of-way than a standard two-lane roundabout. How is this accomplished? At least one entry to a turbo roundabout has a second lane inserted on the central island side. Turbo roundabouts normally have radial design where entering traffic flows directly towards the center of the roundabout. These two elements together allow for a reduction in the outside diameter of the intersection.

Turbo Roundabout Checklist
The following is a summary of design features included in a complete Turbo roundabout:

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

2. USA Projects with Some Turbo Roundabout Features Included

The introduction of Turbo Roundabout design to design engineers in the USA since 2008 has resulted in the use of some of their features in existing and future projects. The following examples are used to illustrate some of the Turbo Roundabout features included in USA projects.

The original roundabout at the entrance to the Utah Valley University roundabout was the first modern roundabout constructed in Utah in 1994. It performed well for almost 20 years but the school has grown from around 10,000 students to over 30,000 students today and most of the students commute to school in single occupant vehicles. The original circle diameter was only 150-ft wide and although it was striped for two lanes it has always functioned as a single lane roundabout.

The proposed design (shown in Figure 6) includes a turbo-style entry on the south that allows two lanes at the entry and within parts of the roundabout. The small size of the circle requires the new lane to be in the inner side of the center island. The entries are all radial design. The diameter is rather small for a two-lane roundabout and may be considered as a “partial turbo roundabout” and with raised divider islands could be considered to be a “full turbo roundabout”.

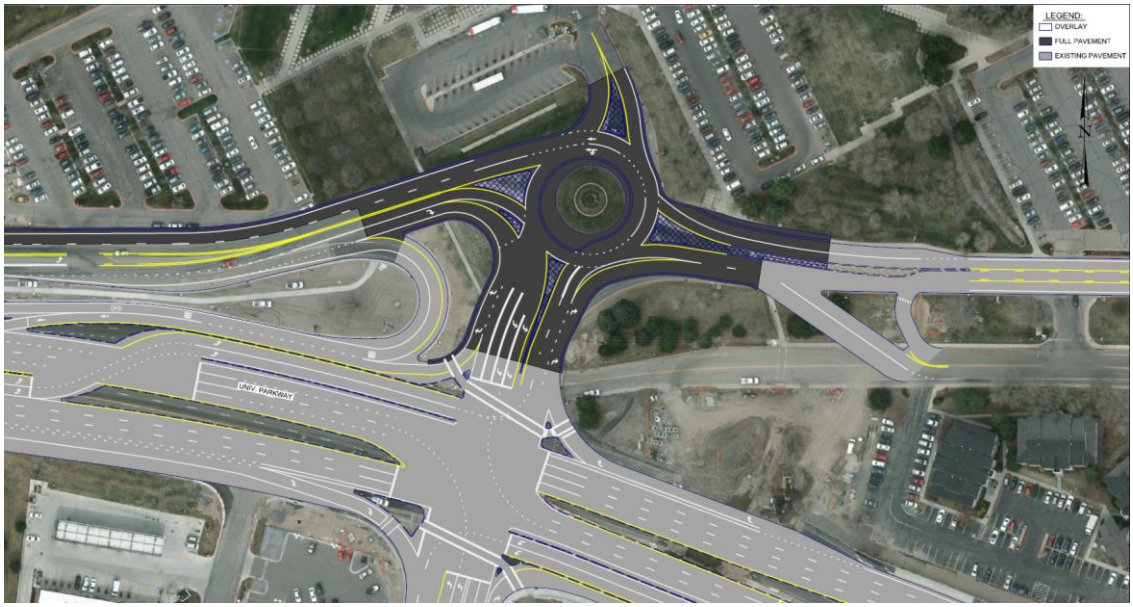

Figure 6. UVU Roundabout First Constructed in 1994, Re-designed in 2014, Orem, UT

This next example is provided to show how with slight modifications an existing roundabout could be considered a “turbo roundabout”. The Tester Road roundabout was constructed in 2001 in Monroe, Washington with mostly radial design and spiral striping. See Figure 7. The inscribed circle diameter is 225-ft. which includes two-lane entries in each direction on Main Street and one-lane entries on Tester Road. If this project was designed today as a turbo roundabout the diameter could be much smaller. If the striping shown below in red color was changed to raised-lane dividers it would function similarly to a turbo roundabout the main difference being that the inside lanes are not inserted into the center island.

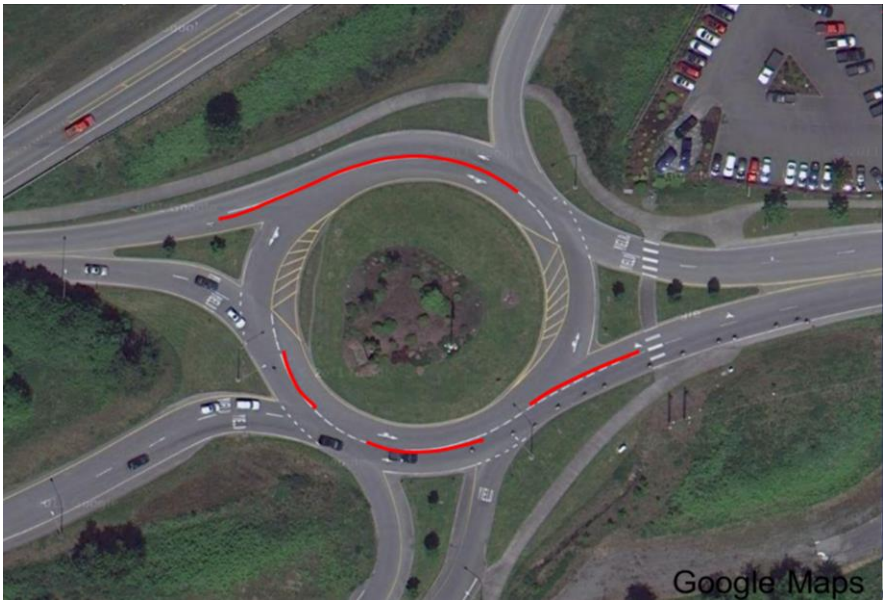

Figure 7. Tester Road Roundabout Constructed 2001, Monroe, WA

3. Deer Valley Roundabout Example

This project example is included to showcase the use of a “mountable raised lane divider island” which is a key turbo roundabout design feature. The modifications shown here were directly inspired by the Turbo Roundabouts in the Netherlands. The Deer Valley Roundabout was constructed in 2000 for the 2002 Winter Olympics in Park City, UT (Figure 8). The roundabout was considered state of the art when it was constructed at a difficult location connecting two ski resorts and a main street shopping area with a new the Olympic Intermodal transit center in Park City. The ski area receives up to 300 inches of snow during the winter and was an ideal location for the Winter Olympics.

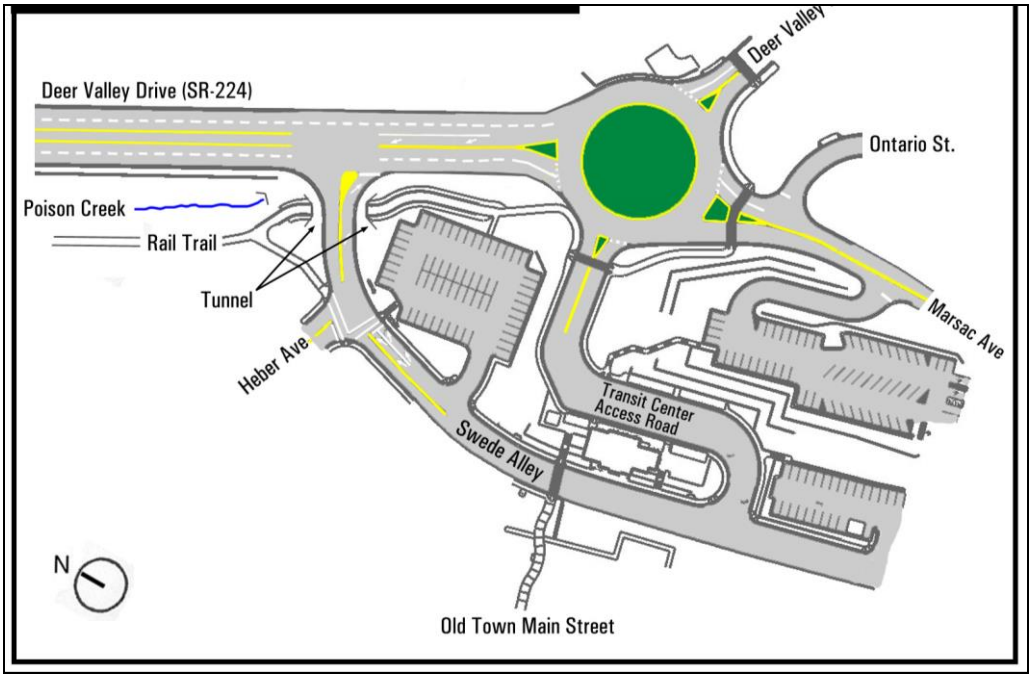

Figure 8. Deer Valley Roundabout Original Concept Design Constructed in 2000

RoundaboutsUSA participated in the original design of the Park City Intermodal Center. The new Intermodal Center included the engineering of a modern roundabout that made it possible for buses to access the intermodal center at a new intersection.

Some of the challenges of the project included the design a modern roundabout to replace a skewed intersection, providing a new connection to the Olympic intermodal center, construction on steep slopes (7% to 14%) and providing a new section of a bicycle/pedestrian trail that required a roadway underpass. (Figure 9)

Figure 9. Deer Valley Roundabout Original Design 2000-2008 Looking South

Deer Valley Roundabout Re-Design in 2008

The original roundabout performed well during the 2002 Winter Olympics and there have been a few minor crashes over the years. During peak hours traffic began to back up to the east into Deer Valley as entering drivers were hesitant to enter the roundabout when circulating traffic volumes were high. The original design attempted to include a right-turn-only bypass lane for traffic on Deer Valley Drive exiting the Deer Valley Ski Resort but it was not included because of environmental impacts to the adjacent Poison Creek.

Looking south

Looking north

Figure 10. Deer Valley Roundabout Raised Lane Divider – Added in 2008

The most significant traffic improvement included in the re-design was a mountable raised lane divider installed to separate westbound to northbound right-turn traffic from heavy northbound traffic. (Figure 10) The lane divider separates traffic leaving Deer Valley ski resort traffic from the main roundabout traffic travelling north. The new configuration can service over 1,000

vehicles per hour (vph) at the northbound exit lanes while the overall entering traffic is over 3,000 vph. The mountable raised lane divider was inspired by the Turbo Roundabouts developed since 2000 in the Netherlands. Vehicle crashes have been reduced slightly for the years 2008-2014 and traffic capacity has improved by 20% but peak hour delays for westbound to northbound traffic have been greatly reduced (by approximately 40%). The mountable raised lane divider is snow-plowable and has helped to reduce the speeds of traffic at the northeast quadrant where it is located. Lane change or weaving type crashes are virtually impossible on the northbound exit of the roundabout. A detailed crash analysis is planned to compare crashes from before the changes were made in 2008 to the after conditions.

The redesign in 2008 added a 2nd entry-lane in the westbound direction from Deer Valley Drive and minor modifications to two of the splitter islands. As a result of the new turning patterns the truck apron was replaced with a wider apron to allow for the added entry-lane and other movements. A detailed layout of the changes made to the Deer Valley roundabout is shown below in Figure 11.

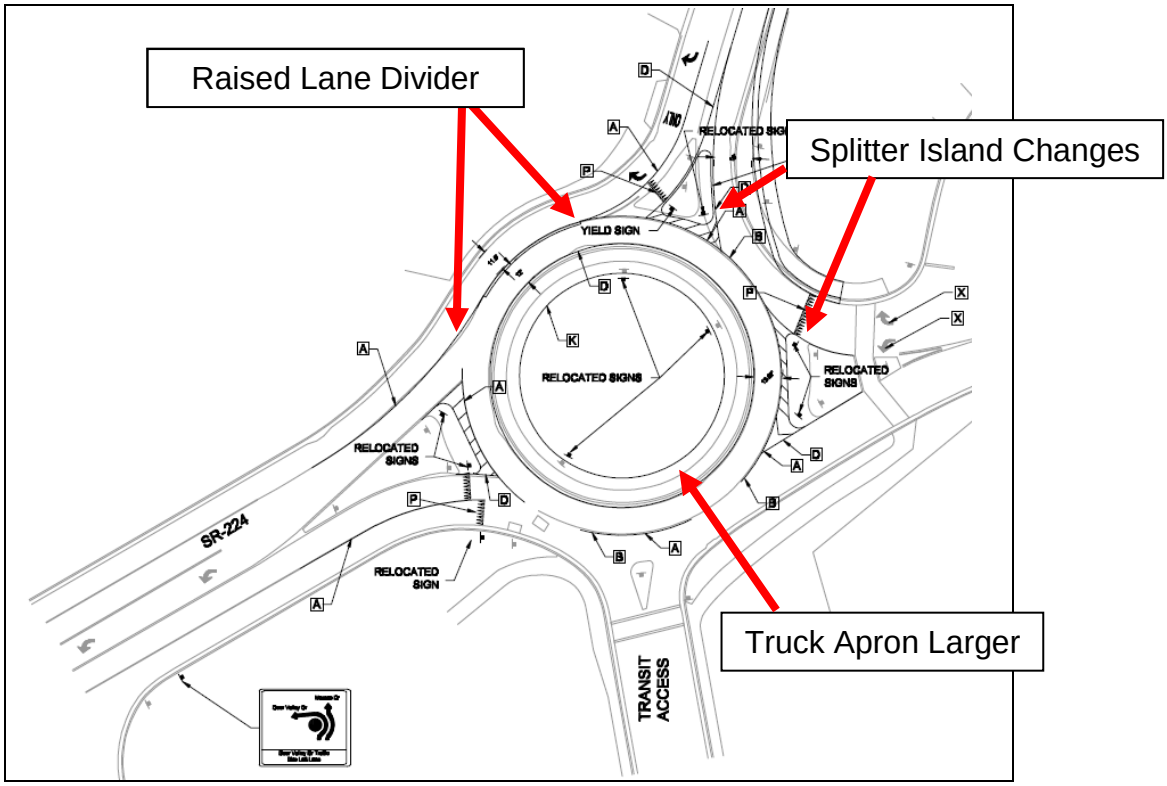

Figure 11. Deer Valley Roundabout Re-design Signing and Striping and Changes in 2008

4. Summary

The following is an attempt to summarize the benefits of a Turbo Roundabout:

- The turbo roundabout eliminates some of the most severe conflict points on a roundabout. On a typical turbo roundabout there are 10 conflict points for vehicles, while on a two-lane roundabout there are 16. This represents 60% more conflict points, which amount to a higher accident risk for a two-lane roundabout.
- The most important feature of the turbo roundabout is the spiral lane marking to eliminate the necessity of weaving or changing lanes. Since weaving in the roundabout is no longer necessary, the lane divider can be slightly elevated. Such a mountable lane divider induces traffic to keep its own lane, and this helps to prevent sideswipe collisions that can occur not only upon entering the roundabout, but also when exiting.
- As a result of the lane dividers, drivers need to choose the correct lane before they enter the roundabout.
- Turbo roundabouts require less right-of-way than a standard two-lane roundabout. At least one entry to a turbo roundabout has a second lane inserted on the central island side. Turbo roundabouts normally have radial design where entering traffic flows directly towards the center of the roundabout. These two elements together allow for a reduction in the outside diameter of the intersection.
- The capacity of a turbo roundabout is about 25 – 35% higher than a standard two-lane roundabout due to improved lane utilization.

The introduction of Turbo Roundabout design to design engineers in the USA since 2008 has resulted in the use of some of their features in existing and future projects. The examples provided to illustrate some of the Turbo Roundabout features included in USA projects.

The new configuration of the Deer Valley Roundabout has improved traffic flow and safety for the past 6 years. It is not yet a “complete Turbo Roundabout”. In the future, as the traffic entering the roundabout increases, Turbo roundabout entries and additional turn lanes inserted inside the circle in the northbound direction may be constructed. The relatively large outer diameter of the roundabout should be able to accommodate the turbo raised lane divider islands to separate left turn traffic from through traffic.

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