

I. RESEARCH ON ROUNDABOUTS

Introduction

Before roundabout case studies are investigated, the importance of roundabouts must be addressed. Roundabouts are useful tools to solve numerous traffic problems in contrasting types of intersections. Roundabouts often increase accessibility, connection, and safety. For instance, Roundabouts reduce vehicle speeds and increase driver attentiveness (“Traffic” 1). At a typical intersection, drivers often speed up to pass through yellow lights. Yet, because of the curved entrances into the roundabouts, drivers reduce speeds upon entrance (Persaud 2). Also, drivers entering the roundabout must yield to the vehicles already on the roundabout (Persaud 2). Furthermore, severe accidents are reduced; this is because conventional intersections often yield t-bone crashes, whereas roundabouts yield angled crashes have less of an impact (“A Guide”). More crash statistics will be addressed later in this report. Roundabouts also cost significantly less than traditional intersections to maintain.

Milestones of Roundabouts

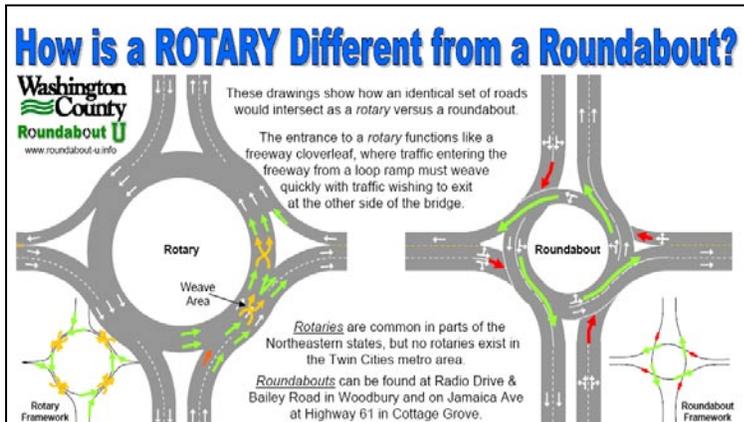
Roundabouts are a growing trend, especially in Europe. In 1993 France built its 10,000th roundabout and five years later increased the total to 20,000 roundabouts (Sides 1). A decade later, France completed its 30,000th roundabout; whereas, in 2007 the United States had just completed its 1,000 roundabout. Momentum to build roundabouts in the United States has been a slow launch. In 1954 the yield control was introduced in the United States (Sides 1). It was not until 1995 and 1996 that Maryland and Florida each completed the first state roundabout guides (Sides 1). The Federal Highway Administrations published Roundabouts: An Informational Guide, and the Insurance Institute for Highway Safety released a major study indicating the benefits of roundabouts in the year 2000 (Sides 1). The outlook of roundabouts was improving in the new decade. In 2005 Congress “makes roundabouts eligible for 100-percent funding under the Safe, Accountable, Flexible, Efficient Transportation Equity Act - A Legacy for Users” (Sides 1).

A typical American response to roundabouts is that the roundabout is a European phenomenon that cannot and should not be implemented in the United States, because the roundabouts are too difficult to navigate. However, the prior data suggests that Congress and the Federal Highway Administration are working to change the negative outlooks of American drivers. These agencies are working to educate the public about the benefits of roundabouts.

These agencies are also working to make roundabouts eligible for special funding to promote the growth. Therefore, an increase of roundabouts in the United States may change American perceptions of roundabouts, especially if safety and efficiency are indeed improved.

Differences between Roundabouts and Rotaries

Roundabouts and rotaries are often confused. The difference is that “the entrance to a *rotary* functions like a freeway cloverleaf—traffic entering the freeway from a loop ramp must weave quickly with traffic wishing to exit at the other side of the bridge [whereas] roundabouts are used for safety and efficiency (“How” 1). Thus, roundabouts slow traffic and increase driver efficiency.



Rotaries are usually entered alongside other traffic that is already circulating in the ramp (“How” 1). Roundabouts, however, must always yield to all traffic in the roundabout regardless of the lane they are in. Rotaries do not contain intersections, lanes are just added or dropped, and the right lane of a rotary does not need to merge (“How” 1). Roundabouts, however, are a series

of intersections that cross; furthermore, vehicles must yield to the right of way of all traffic coming from the left (“How” 1).

The overall design of a rotary is not striped even though vehicles may travel along side of each other and frequently change lanes (“How” 1). The roundabout, however, is striped as a spiral; in addition, vehicles shall not change lanes within the roundabout should chose the lane before entering (like a typical roundabout).

Rotaries are typically large, entry speeds are 40 mph or higher, and work well at low volumes (“How” 1). Roundabouts are typically small and speeds rarely excess more than 25 mph (“How” 1). Rotaries excel at low traffic volumes; whereas, roundabouts typically handle heavy traffic because of the focus on efficiency and safety (“How” 1).

Because of the high speeds, lane changes, and merging, rotaries are often perceived as dangerous. The confusion of rotaries and roundabouts yields confusion that roundabouts are dangerous. Yet, roundabouts are used to slow speeds and increase efficiency, safety, and driver attentiveness.

Safety

The National Cooperative Highway Research Program states that a “substantial reduction in injury accidents has been the primary reason for the great success of modern roundabouts in France and in Germany. The significant decline in crashes occurs because of the reduction of

points of conflict. Points of conflict are areas in which accidents with other cars, pedestrians, or bicyclists can occur (see FIGURE 1a). Limiting traffic and separating the movements through

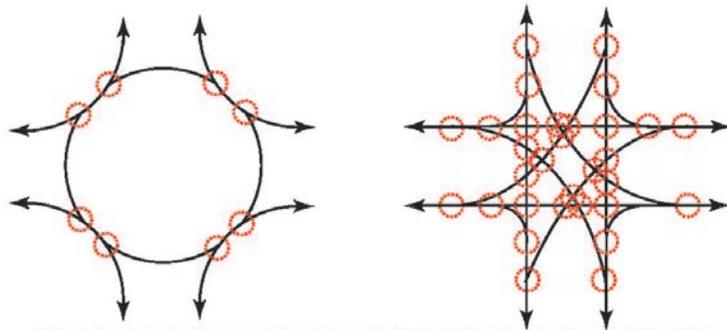


FIGURE 1a
This diagram illustrates points of conflict.
Source: Banks 29

the use of splitter islands reduces the number of conflict points to eight in a roundabout in comparison to a common four-way intersection with a total of 32 possible conflict points (Persaud 2).

Many studies have proved this finding. For instance, Schoon and van Minnen investigated 181 Dutch intersections that were transformed from a traffic signal or stop sign intersection to a roundabout

(Persaud 2). The study found that crashes and injuries decreased by 47 in the former traffic signal and 71 percent in the former stop sign intersections. Furthermore, the severe injury crashes were reduced by 81 percent (Persaud 2). Similarly, Troutbeck reported an average of 74 percent decrease in the rate of injury crashes at 73 intersections in Australia that were converted from typical signal designs to roundabouts (Persaud 2). Elvik supports this conclusion with the finding that conversion of a yield, two-way stop, or traffic signal control to a roundabout lessens the total of injury crashes by 30-40 percent (Persaud 2). Furthermore, bicycle crashes were lessened by 20 percent (Persaud 2). The number of accidents involving pedestrians was decreased by 30 percent. Pedestrians are also typically safer because of several reasons. Pedestrians do not actually cross the roundabout, they circumnavigate or cross the vehicular entrances (Persaud 2). At the vehicular entrance crossways, the splitter islands allow for safer crossings because pedestrians do not have to jolt continuously cross two lanes of traffic. Instead, the pedestrian cross one lane of traffic, break in the splitter island, then cross the other lane of traffic. Furthermore, pedestrian crossings are placed one car length from the entry point (Persaud 2).

According to the National Cooperative Highway Research Program “All of the survey respondents agreed that U.S. roundabouts performed well in terms of the following criteria: shorter delays, increased capacity, improved safety, and improved aesthetics” (Jacquemart 32). Also, the study showed that “delay measurements at seven roundabout sites showed that the peak-hour delays decreased by about 75 percent, in relation to the previous traffic control. Before-and-after crash statistics at 11 existing roundabouts showed a reduction of 37 percent in total crashes, 51 percent in injury crashes, and 29 percent in property damage-only crashes. For the eight small-to-moderate-size roundabouts, with an outside diameter of up to 37 m (121 ft), the crash reductions were statistically significant for total crashes (a reduction of 51 percent) and for injury crashes (a reduction of 73 percent)” (Jacquemart 32).

Average Frequency of Annual Crashes (Banks 25)

Before Roundabout			After Roundabout			Percent Change		
Total	Injury	PDO	Total	Injury	PDO	Total	Injury	PDO
21.5	5.8	15.7	15.3	4.0	11.3	-29%	-31%	-10%



Benefits to the Environment and Aesthetics

Research suggests that roundabouts are more beneficial for the environment than typical intersections. Because “drivers do not have to wait as long at roundabouts as at signalized intersections, roundabout[s are] friendlier to both the driver and to the environment” (Jacquemart 12). Roundabouts allow for a steady stream of traffic which prevents drivers from idling a car and wasting gas. In addition “the reduced amount of paved areas and the reduction in noise and air pollutant emissions are also cited in the European literature as advantages for roundabouts. Field measurements in Sweden showed reductions in pollutant emissions and fuel consumption in the range of 21 to 29 percent” (Jacquemart 12). If designed correctly, roundabout design can benefit the environment. Roundabouts can include pervious treatments to absorb runoff. Roundabouts are also such an important roadway feature, because they have the potential to serve as gateways, especially if the roundabouts are placed in strategic areas such as main intersections. The center medians can be transformed into gardens, contain statues or public art, and be a symbol for the community. Roundabouts essentially have the potential to redefine an image of a community through the transformation of a roadway intersection.

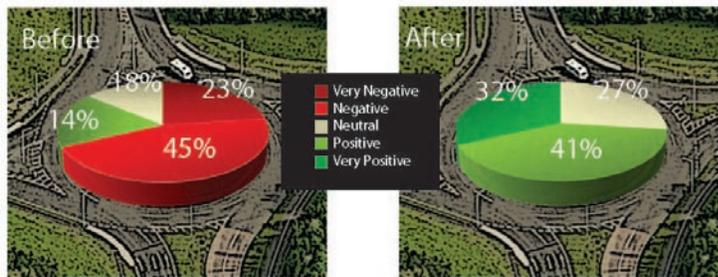
Costs and Economic Impact

Roundabouts also cost significantly less than conventional intersections. Conventional traffic light intersections require an average of \$125,000 of equipment (“A Guide”). Also, the electricity costs \$8,000 to \$10,000 per stop light each year (“A Guide”).

Findings also show that roundabouts improve the surrounding commercial venues. In 1999 Golden, Colorado changed four intersections into roundabouts. They created a commercial roundabout district. This district had experienced a decrease in injury crashes by 94 percent, and a decrease in overall crashes by 88 percent. Also, the commercial district experienced a sales tax revenue increase of sixty percent which resulted because of the traffic volumes that increased by 35 percent (more customers), speeds that decreased by 30 percent (more time to be allured by signs of stores), and increased traffic volumes of 35 percent (Sides 2).

Roundabouts not only cost less to maintain than typical intersections, but also have the capability to improve the appeal of an area. Roundabouts often refresh the image of a community; after all, the new roundabout consists of new pavement and signs. The fresh image allures people to the area. More people yield more customers.

Responses to Roundabouts in the US



A survey of approval of the Montpelier, Vermont roundabout was conducted before and after construction (Banks 22).

According to the National Cooperative Highway Research Program “A survey of residents and workers near the Montpelier, Vermont roundabout indicated that 56 percent of the respondents had a favorable opinion of the roundabout, 29 percent had a neutral opinion, and 15 percent had an unfavorable opinion. Of the 106 respondents, 93 percent had driven through the roundabout, 82 percent had walked through the roundabout, and 18 percent had bicycled through the roundabout. No differences in opinion were discerned among the drivers, pedestrians, and bicyclists” (Jacquemart 20).

After the first American prestigious roundabout in Clearwater, Florida was proposed, many of the residents protested the new road project (Sides 2). However, after the Clearwater Beach Entryway Roundabout opened in 1999, the residents and business owners presented the City of Clearwater funding to encourage the construction of a second roundabout (Sides 2). In the following years, residents of Clearwater rallied the City to convert 14 more intersections into roundabouts (Sides 2).

These examples exemplify the initial, negative reaction to roundabouts in the United States. However, once the roundabouts are installed and properly working, the citizen approval drastically changes. Citizens even demanded more roundabouts. Therefore, those with power to implement roundabouts should not waver the implantation based on citizen’s initial opposition, because it is very likely that the citizens will approve the roundabout once the roundabout is installed and properly operating.

II. Roundabouts Along Interstates—Roundabout Interchanges

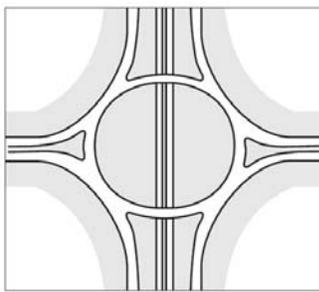


FIGURE IIa
6. Department of Transport (United Kingdom),
Geometric Design of Roundabouts, TD 16/93,
September 1993.

Introduction

Roundabouts that occur at freeway ramp junctions and arterial roads are known as roundabout interchanges (“System” 219). Ideal situations for roundabout interchanges are as follows: “Limited queue storage space on bridge crossing, off-ramps, or arterial approaches. In such circumstances, roundabouts operating within their capacity are particularly amenable to solving these problems

when compared with other forms of intersection control” (“System” 219).

Types of Roundabout Interchanges

There are two basic types of roundabout interchanges: the one bridge interchange and the two bridge interchange. One type is a large diameter roundabout centered over or under a freeway (see FIGURE IIa). The legs of the crossroad and ramps directly connect to the roundabout (“System” 219). This type of roundabout interchange requires two bridges, and the bridges may be curvilinear (“System” 220). The freeway may go over the roundabout. Therefore, the



FIGURE IIb
This photo illustrates A50/Heron Cross, United Kingdom (the image is mirrored to show right-hand-side driving)
Source: “System” 220

freeway may require four bridges, “depend[ing] on the optimum span of the type of structure compared with the inscribed diameter of the roundabout island and on whether the one bridge is used for both freeway directions or whether there is one bridge for each direction. The road cross-section will also influence the design decision” (“System 220). A two-bridge roundabout interchange can include two consecutive interchanges, such as the A50/Heron Cross in the United Kingdom. The interchanges are connected with access roads. This circumstance may be appropriate in instances of connecting parallel one-way streets. The other type of roundabout interchange, the one-bridge roundabout, includes a roundabout at each side of the freeway (see FIGURE IIc). This type of roundabout “defers the need to widen bridges. Unlike signalized



FIGURE IIc
This photo illustrates a one bridge roundabout interchange
Source: “System” 220

ramps that may require exclusive left-turn lanes across the bridge and extra queue storage, this type of roundabout interchange exhibits very little queuing between the intersections since these movements are almost unopposed. Therefore, the approach lanes across the bridge can be minimized” (“System” 220).

The performance of an interchange roundabout is equivalent to single typical roundabout (“System” 222). Similarly, the positive and negative attributes of the

interchange roundabouts are concurrent to a single roundabout (“System” 222). The highest entrance capacity is reliant on the flow and the shape of the roundabouts (“System” 222). The queue length on the off-ramps at roundabout interchanges are typically less than at a conventional, signalized intersection. In addition, if the roundabout operates below capacity, “the performance of the on-ramp is likely to be better than if the interchange is signalized, [because] the headway between vehicles leaving the roundabout along the on-ramp is more random than when signalized intersections are used [and the] more random ramp traffic allows for smoother merging behavior on the freeway and a slightly higher performance at the freeway merge area compared with platooned ramp traffic from a signalized intersection” (“System” 222).

Roundabouts have the potential to alleviate traffic along interstates, off-ramps, and the connected arterials. Roundabout interchanges can be used to connect parallel, one-way streets. Roundabout interchanges can also be used to connect two-way streets to the interstate ramps. Roundabout interchanges are fairly malleable and can be used in a number of situations to alleviate traffic and increase accessibility and connectivity.

III. Case Studies

Greater Cincinnati Area Roundabouts



FIGURE IIIa
This photo illustrates the Fairfield Township Roundabout in Cincinnati, Ohio.
Source: Pictometry Online



FIGURE IIIb
This photo illustrates the Lakota Drive Roundabout in Cincinnati, Ohio.
Source: Pictometry Online

Roundabouts do mark the urban fabric of the Greater Cincinnati Area—yet, there are only a couple of roundabouts in the entire metropolitan area. One of the roundabouts, is located in Eden Park. The City of Cincinnati installed a roundabout at the intersection of Eden Park Drive and Fulton Avenue. The roundabout was intended to slow motorists .

Construction was finished on a single lane roundabout in Fairfield Township (see FIGURE IIIa). The roundabout will be located at the intersection at Hamilton-Mason and Vinnedge roads (Kiesewetter 1). The overall project will cost \$1 million. Simulations and studies have shown “90 percent reduction in fatal crashes, 75 percent in injury crashes and 30-40 percent in pedestrian crashes” (Kiesewetter 1). The roundabout will be build by W.G. Stang LLC. Funding will provided by Ohio Public Works Commission that will grant 46 percent of the

funding for the project. The other funding will come from county dollars and a \$50,000 contribution from Fairfield Township (Kiesewetter 1). Another roundabout, a single lane roundabout, was implemented in Lakota Drive West and Eagleridge Drive in West Chester Township (see FIGURE IIIb). Because both of these roundabouts are new projects, no crash study statistics are available for analysis.

Vail, Colorado Roundabouts

Literature Review: "Roundabout Interchanges"

"Roundabout Interchanges." Ourston. <<http://www.ourston.com/index.php?id=71>> (See Appendix A)

The article entitled "Roundabout Interchanges" describes the towns of Avon and Vail Colorado. The towns eliminated traffic congestion through a very innovative tool: roundabouts. The cities "built high-capacity modern roundabouts at nine intersections which had caused long delays. Six roundabouts replaced Interstate 70 ramp intersections formerly regulated by STOP signs, and three roundabouts replaced signalized cross intersections in downtown Avon" ("Roundabout" 1). Vail Valley, Colorado sets the precedent and national example of proper roundabout use. Residents initially opposed the roundabouts in the city. Yet, after one pair was implemented, the towns demanded for more. Eventually, most of the intersections in Vail Valley were converted into roundabouts.

The roundabout projects began in 1995. In 1995, Interstate 70 through the Rocky Mountains became a roundabout corridor with the completion of the first of four roundabouts. The implementation of ten more roundabouts quickly ensued ("Roundabout" 1). The eight year project was finished in 2003.

Currently, the Vail Valley in Vail has three modern roundabout interchanges and has been coined "'Roundabout Valley,' the showcase for high-capacity roundabouts on this continent" ("Roundabout" 1). The article describes the costs and safety improvements of the roundabouts. The article also describes to conventional roundabouts on roadways throughout the Vail Valley that have replaced typical intersections.

The article describes the American approach to traffic to hurry-up-and-wait, or "accelerate from one signal and hurry to the next one, only to stop for two minutes at a red light." The article states that the "average speed along a 45 mile-per-hour road may be as low as 15 miles per hour when stopped time at red lights is considered" ("Roundabout" 1). The article describes Britain's approach to traffic: "always flowing [because] British intersections are predominantly T-intersections (each regulated by one side-street YIELD sign) [and] major intersections are roundabouts, regulated by the yield-at-entry rule. These two types of low-delay intersection keep traffic flowing" ("Roundabout" 1). The article compares the American traffic system and British traffic system essentially saying that Britain has phased out many of the road practices of American roads.

Precedent

Because the freeway interchanges of Vail, Colorado became badly overcrowded, citizens pressed for a new design (Vail 1). Initially, civil engineers proposed a conventional solution which involved \$15 million worth of off-ramps, the widening of overpasses, and new traffic lights (Vail 1). However, some residents were concerned that this design that encompassed too much concrete would decimate the bucolic charm of the mountain town. Residents demanded a smaller and greener alternative that was friendly to bicyclists and pedestrians (Vail 1). Consequently, Council overturned the initial proposal and instead voted in favor for a \$2.2 million pair of modern roundabouts on each end of the interchange (Vail 1). Numerous residents argued against the roundabout and even protested the roundabout in the newspaper for six months (“Roundabout 4). However, Council pushed through the plans.

The first Vail, Colorado roundabout built in 1995 was the first roundabout interchange built in North America (“Roundabout” 1). The intersection was formerly regulated by stop signs but was replaced by two roundabouts; the roundabouts were each two and three lane entries (“Roundabout” 1). Roundabout one, West Bound I-70 Ramp at Vail Road, is a raindrop design. The diameter of the circle is 120 feet, and five legs lead to the roundabout. The roundabout has a capacity of 2,700 vehicles per hour (“Avon” 2). The second roundabout, East Bound I-70 Ramps at Vail Road and South Frontage Road, is a six-leg roundabout. The roundabout is circular in design and includes a diameter of 200 feet. The capacity is 5,200 vehicles per hour (“Avon” 2). ARCADY/RODEL guided the implementation of the roundabouts. The total cost of the 1995 construction was \$2.8 million; furthermore, the roundabout saves \$85,000 each year on money that was previously spent on traffic direction officers (“Roundabout” 1). Also, the queues that used to expand onto the freeway, now seldom exceed ten automobiles (“Roundabout” 1). The crash rate for the first year of operation dropped to 22 crashes in the after period from a yearly average of 25 crashes in the before period. Injury crashes decreased to three from an average of five. The project received a high approval rating, 4.4 on a scale of 5.

After a process of twelve neighborhoods meetings in 1996 (a year after the implementation of the first pair of roundabouts), residents showed approval of the first pair of roundabouts. Therefore, residents demanded for the implementation at another Vail interchange—Interstate 70 and Chamonix Roads. The third roundabout, the West Bound I-70 Ramp at Chamonix Road, is a six leg roundabout. The roundabout has a diameter of 150 feet. The capacity of the roundabout is 3,700 vehicles per hour. The fourth roundabout, the East Bound I-70 Ramp at Chamonix Road, has six legs and a capacity of 3,300 vehicles per hour. The roundabouts at the Vail West Entrance were opened in 1997 (“Avon” 2). Currently, “traffic at every exit from an interstate highway entering Vail is governed by a roundabout” (“Roundabout 1”). Furthermore, the traffic delays and backups have mostly disappeared (“Roundabout 1”). In addition, the director of public works and transportation in Vail, Greg Hall, states that crashes reduced by 20 percent from three years before the first roundabout was implemented to three years after the roundabout was implemented. Furthermore, crashes that resulted in injuries decreased by eighty five percent (“Avon” 3).



FIGURE IIIc
 This photo illustrates the Avon Road Corridor.
 Source: "Avon" 1

The form of the roundabout is a strength for the City of Vail. After the interchanges were implemented along the interstate, the roundabout became a choice for roadway intersections. The Avon Road corridor consists of five roundabouts. The first roundabout, West Bound I-70 Ramps consist of a multi-lane roundabout in a tear-drop design. The diameter measures 150 feet. The roundabout has a capacity of 4,200 vehicles per hour. Four legs approach the roundabout intersection. This roundabout opened in 1997 ("Avon" 1).

The second roundabout that is located on the East Bout I-70 Ramps consists of another tear-drop roundabout with a diameter of 150 feet. This roundabout is multi-lane and has a capacity of 5,800 vehicle per hour. This roundabout has four legs that approach. This roundabout opened in 1997 ("Avon" 1).

The third roundabout, located on Beaver Creek Road, is a multi-lane roundabout in an oval design. The oval has a 75-foot radius tips and 200-foot radius sides. This roundabout has a capacity of 6,000 vehicles each hour. This roundabout replaced a signalized intersection. The project was completed in 1997. This is the largest roundabout along Avon Road ("Avon" 1).

The fourth roundabout, Benchmark Road, was constructed on a sharp crest vertical curve. The roundabout is a raindrop design and consists of a diameter of 150 feet. This roundabout is unique, because circulation is prevented from its lower side because of the five percent cross slope that would be dangerous to trucks. With just the two-lane entries, the roundabout has a capacity of 4,300 vehicles per hour ("Avon" 1).

The fifth roundabout is the SH- 6 multi-lane roundabout. The roundabout consists of four legs, one being the entrance to a ski resort, and a diameter of 150 feet. The capacity of the roundabout is 4,900 vehicles per hour. The roundabout was opened in 1997 ("Avon" 1).

The roundabouts not only preserved the mountain charm, but increased safety and efficiency along the corridor. The project significantly promises sustainability. For instance, as mentioned before in this essay, drivers spend less time idling gas at a conventional traffic signal. Less idling leads to fewer emissions that pollute the environment. Furthermore, safety is a major attribute to environmental sustainability. Roundabouts, in this instance, have proved to fare better than typical intersections.

This examples shows that it is typical to initially reject the notion of roundabouts. However, the citizens changed their opinions once the roundabouts were actually implemented. The towns even demanded that nearly every intersection contain a roundabout. Lessons that can

be learned from this case study are as follows: eliminating traffic congestion can be mitigated through the use of modern roundabouts at prominent intersections, roundabouts are more efficient and typically safer than conventional signals and cross intersections, and the cost of widening the intersection links (tunnels or bridges for example) is far more expensive than widening the nodes (roundabout interchange).

IV. Conclusion

Roundabouts are much more than a street device. Roundabouts have the potential to transform an area. Not only is a roundabout a radical improvement to a roadway, but roundabouts can be used as a visual enhancement to an area as a gateway. Roundabouts are an tool that increases safety along the street, enhances driver attentiveness, reduces automobile idling, and efficiently streams traffic through an area. Roundabouts are cost effective and save thousands of dollars that traditional intersections require for the electricity of signals. Even though many people are skeptical about roundabouts—thinking they are confusing, overwhelming, and hinder traffic flow—studies have proved the opposite. The more roundabouts that are implemented and effective, the more drivers will be accepting. It is only a matter of time that roundabout implementation in the United States will match the Europeans.

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VI. Appendix A

Roundabout Interchanges

Roundabout Valley

The Colorado Rocky Mountain towns of Avon and Vail did what many of us wish our own home towns and cities would do. They eliminated traffic congestion.

They built high-capacity modern roundabouts at nine intersections which had caused long delays. Six roundabouts replaced Interstate 70 ramp intersections formerly regulated by STOP signs, and three roundabouts replaced signalized cross intersections in downtown Avon.

Now there are three modern roundabout interchanges in the Vail Valley, about one hundred miles west of Denver, Colorado. With these major roundabouts, the Vail Valley has become America's "Roundabout Valley," the showcase for high-capacity roundabouts on this continent.

North America Now: Hurry Up and Wait

Traffic on North America's arterial streets may be characterized by four words: hurry-up-and-wait. Motorists accelerate from one signal and hurry to the next one, only to stop for two minutes at a red light. The average speed along a 45 mile-per-hour road may be as low as 15 miles per hour when stopped time at red lights is considered.

A proliferation of STOP signs is another major factor in North America's hurry-up-and-wait system. STOP signs are often installed where, because of ample sight distance, prudent drivers do not stop; we simply yield. We slow to see whether vehicles are approaching on the through street, but we do not completely stop unless there is a reason to stop. YIELD signs would improve compliance with the law at these high-visibility locations. Roundabout Valley eliminated 37 STOP signs. This is suggestive of North America's future.

Britain Now: Always Flowing

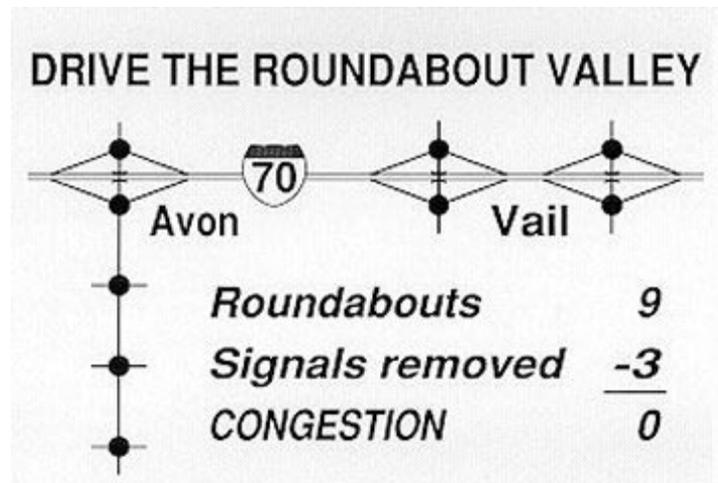
By contrast, British traffic may be characterized by two words: always flowing. Although at peak hours Britain has long delays at some over-capacity intersections, during off-peak hours one can drive British surface roads through cities, suburbs, and towns for many miles without stopping. British intersections are predominantly T-intersections, each regulated by one side-street YIELD sign. Major intersections are roundabouts, regulated by the yield-at-entry rule. These two types of low-delay intersection keep traffic flowing. STOP signs are used very sparingly, at intersections having impaired sight distance.

The four-way cross intersection, the favorite type of intersection in North America, has been rendered obsolete in Britain. It is superseded by the roundabout, which carries heavy flows of traffic with greater safety and efficiency. Avon, Colorado, has replaced every cross intersection on Avon Road with a roundabout. This is suggestive of North America's future.

Study Roundabout Valley

In a nine-mile area the highway researcher will find roundabout variety not available anywhere else in the continent:

- 9 high-volume roundabouts.
- 3 roundabouts that have replaced signalized cross intersections.
- 4 raindrop-type roundabouts.
- 4 full-circle roundabouts.
- 1 oval roundabout.
- 8 right-turn bypass lanes.
- 25 flared entries.
- 4 one-lane entries.
- 22 two-lane entries.
- 8 three-lane entries.
- 6 freeway off-ramp entries.



Lessons that can be learned from Roundabout Valley:

- The modern way to eliminate traffic congestion is to build roundabouts at the most heavily impacted intersections.
- Roundabouts eliminate congestion, leaving beauty in its place.
- Roundabouts are safer and more efficient than traffic signals.
- Roundabouts are safer and more efficient than cross intersections.
- It usually costs much less to widen nodes than to widen links, especially where links are expensive, as at interchanges, at the ends of tunnels and bridges, and through built-up areas.

I-70/Vail Road, Colorado, 1995

The Town of Vail, Colorado, built the first roundabout interchange in North America at Interstate 70/Vail Road in 1995. Closely spaced ramp and frontage road intersections, formerly regulated by STOP signs, were replaced by two roundabouts, with two- and three-lane entries. The six-leg south roundabout has an inscribed circle diameter (ICD) of 200 feet and a capacity of 5,200 vehicles per hour; the five-leg raindrop-type north roundabout has an ICD of 120 feet and a capacity of 2,700 vehicles per hour. The work was guided by the application ARCADY / RODEL.

The total cost of the project was \$2.8 million. The project saves the town \$85,000 per year on traffic direction officers. Long queues, which used to extend back onto the freeway, now rarely exceed ten vehicles.

The crash rate for the first year of operation dropped to 22 crashes in the after period from a yearly average of 25 crashes in the before period. Injury crashes decreased to three from an average of five. The project received a high approval rating, 4.4 on a scale of 5.

I-70/Chamonix Road, Colorado, 1997

Following a series of twelve neighborhood meetings in 1996 to consider options for Vail's second most impacted interchange, I-70/Chamonix Road, it became clear that residents wanted a modern roundabout interchange like the one built a year earlier at I-70/Vail Road. The new interchange was designed and built in one year, light speed for highway engineering projects. Opened in the summer of 1997, the roundabouts have eliminated traffic congestion at the interchange.

Each of the two roundabouts has an inscribed circle diameter of 150 feet, and each has six legs, two bypass lanes, and two-lane entries. The peripheral pedestrian-bicycle road crosses Gore Creek twice. The north roundabout has a capacity of 3,700 vehicles per hour, and the south one has a capacity of 3,300 vehicles per hour.

Avon Road, Colorado, 1997

In Avon, Colorado, a town nine miles southwest of Vail, voters increased their own property taxes to pay for North America's longest wide-node-narrow-link road. Five roundabouts relieve traffic congestion along the entire length of Avon Road, the only connection to Interstate 70 for the towns of Avon and Beaver Creek. The roundabouts were opened in the fall of 1997.

I-70/Avon Road has two 150-foot-diameter raindrop-style roundabouts. Entries to the north roundabout have three-lanes, and entries to the south roundabout have two-lanes. Three right-turn bypass lanes boost the capacity of the interchange to 4,200 vehicles per hour through the north roundabout and 5,800 vehicles per hour through the south roundabout.

The southerly three roundabouts have replaced three signalized cross intersections:

- At Beaver Creek Road, an oval roundabout with 75-foot-radius tips and 200-foot-radius sides has a capacity of 6,000 vehicles per hour. Entries have two and three lanes.
- At Benchmark Road, a 150-foot-diameter raindrop-style roundabout built on a sharp crest vertical curve prevents circulation around its low side. If left open to full circulation, a five-percent adverse cross slope on the low side would be hazardous to trucks. Drivers of fire and police vehicles can remotely actuate a lift-

gate through the tip of the central island. With two-lane entries, the roundabout has a capacity of 4,300 vehicles per hour.

- At U.S. Highway 6, a 150-foot-diameter roundabout with two-lane entries has a capacity of 4,900 vehicles per hour.

Source: "Roundabout Interchanges." Ourston. <<http://www.ourston.com/index.php?id=71>>