FROM FEDERAL HIGHWAY ADMINISTRATION MEMO OF JULY 10, 2008

Subject: Consideration and Implementation of Proven Safety Countermeasures
From: Jeffrey A. Lindley, Federal Highway Associate Administrator for Safety

Modern roundabouts have geometric features providing a reduced speed environment that offers substantial safety advantages and excellent operational performance.

"The modern roundabout may be the safest, most efficient traffic control device available today."
-- Discover Magazine, June 2001, page 75

Roundabouts have demonstrated substantial safety and operational benefits compared to other forms of intersection control, with reductions in fatal and injury crashes of from 60–87 percent. The benefits apply to roundabouts in urban and rural areas and freeway interchange ramp terminals under a wide range of traffic conditions. Although the safety of all-way stop control is comparable to roundabouts, roundabouts provide much greater capacity and operational benefits.

Roundabouts can be an effective tool for managing speed and transitioning traffic from a high speed to a low speed environment. Proper site selection and channelization for motorists, bicyclists, and pedestrians are essential to making roundabouts accessible to all users.

In particular, it is important to ensure safe accommodation of bicyclists at higher speed roundabouts and for pedestrians with visual or cognitive impairments.

While many associate the circular intersection with Europe, America was actually the first country to use the concept with a rotary system in Columbus Circle, NY, in 1905.

GUIDANCE STATEMENT/APPLICATION

Roundabouts are the preferred safety alternative for a wide range of intersections. Although they may not be appropriate in all circumstances, they should be considered as an alternative for all proposed new intersections on Federally-funded highway projects, particularly those with major road volumes less than 90 percent of the total entering volume.

Roundabouts should also be considered for all existing intersections that have been identified as needing major safety or operational improvements. This would include freeway interchange ramp terminals and rural intersections.

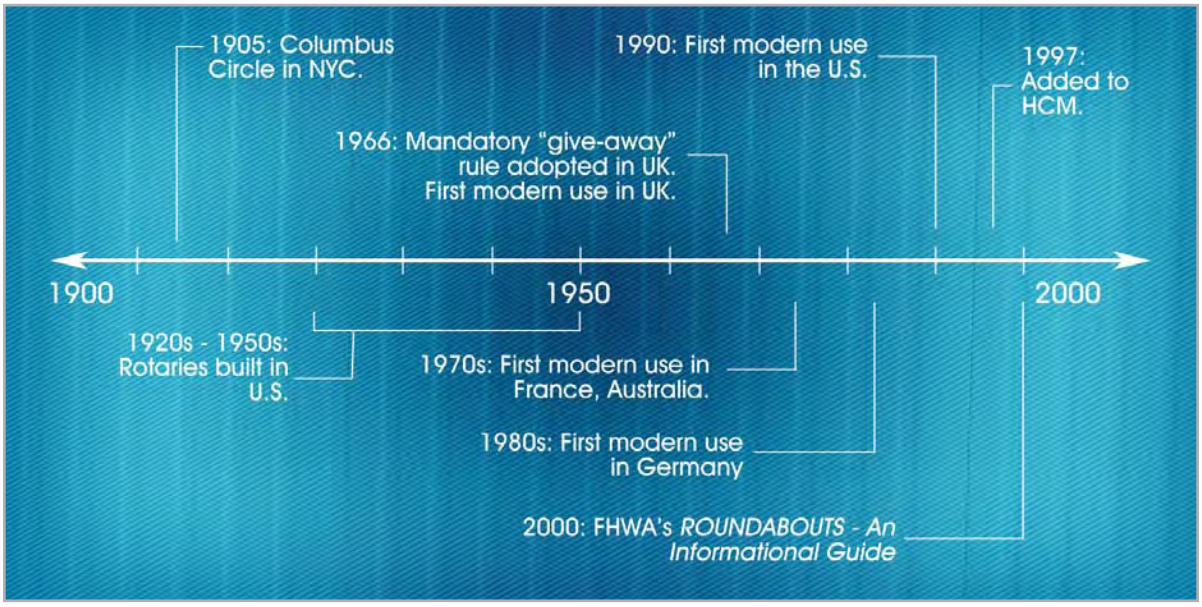
AREN'T ALL CIRCLES IN THE ROAD A ROUNDABOUT?

There are several types of circular intersections in use in the United States including such things as Rotaries and Traffic Circles sometimes referred to as gyratory systems.

Roundabouts have unfairly received a bad reputation, which derives from older, unsafe designs. A traditional, high-speed rotary circle was meant to function like an expressway, with entering traffic merging with traffic in the roundabout.

While some may be justified for disliking the roundabout concept because of experience with earlier versions, the last 40+ years have brought many improvements to the concept including "giving way" or making the entering traffic yield.

Note the new modern roundabout being built inside of an old traffic rotary in the picture above.

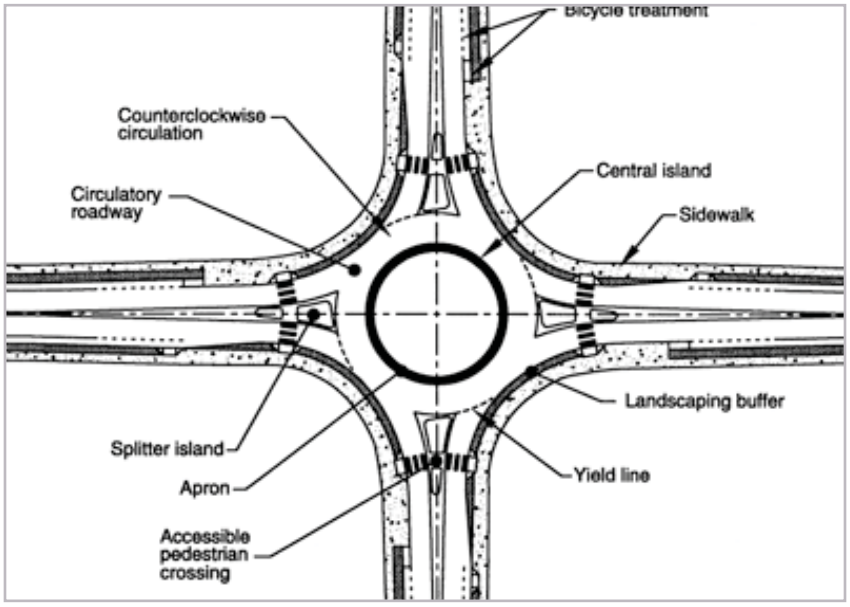


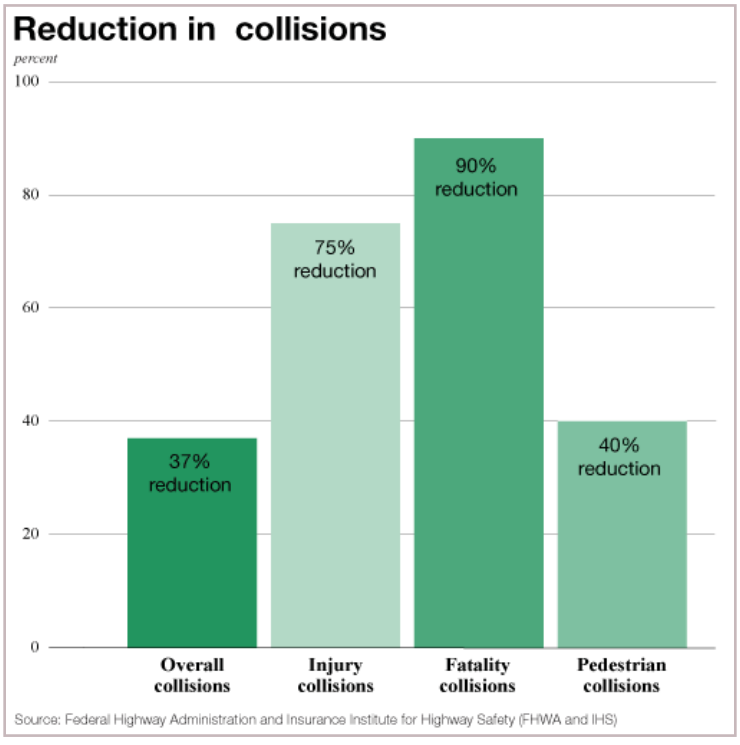
Modern roundabouts are only superficially similar to Rotaries and Traffic Circles. Modern roundabout design is based on extensive research and engineering experience derived over the years on roundabouts being constructed around the world. These improved designs have enhanced the safety and efficiency of most traffic intersections. Many communities in the United States have now implemented roundabouts with great success.

SO WHAT IS A MODERN ROUNDABOUT?

The modern roundabout is a type of circular intersection defined by the basic operational principle of entering traffic yielding to vehicles on the circulatory roadway and certain key design principles to achieve deflection of entering traffic by channelization at the entrance and deflection around a center island. The modern roundabout is distinguished by five key elements:

- YIELD control on entry
- Priority to circulating vehicles
- Pedestrian access & crossing
- Lack of Parking
- Deflection of vehicle paths (speed control)





WHAT ARE THE BENEFITS OF A MODERN ROUNDABOUT?

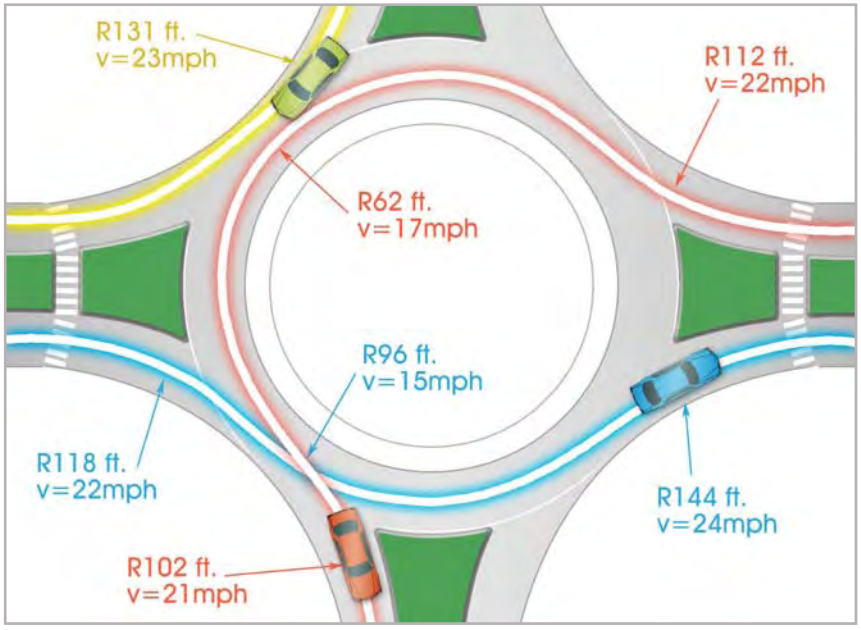
Roundabouts are being used to improve safety, increase intersection capacity and efficiency, reduce environmental impacts, and enhance community values. Additional benefits include lower costs over other types of intersections and greater design flexibility.

Improved Safety

Several features of the modern roundabout promote safety. The safety benefits alone should be enough to convince roundabouts are a great idea. According to a study by the Institute for Highway Safety of locations where stop signs or traffic lights were replaced by roundabouts, all crashes were reduced by 39 percent and serious crashes fell by 76 percent, including a 90 percent reduction in fatalities. This means not only fewer crashes, but also most will be able to walk away from them.

At traditional intersections, some of the most common types of crashes are right-angle, left-turn, and head-on collisions. These types of collisions can be severe because vehicles may be traveling through the intersection at high speeds to “beat the red light”. With roundabouts, these types of potentially serious crashes essentially are eliminated because vehicles travel in the same direction.

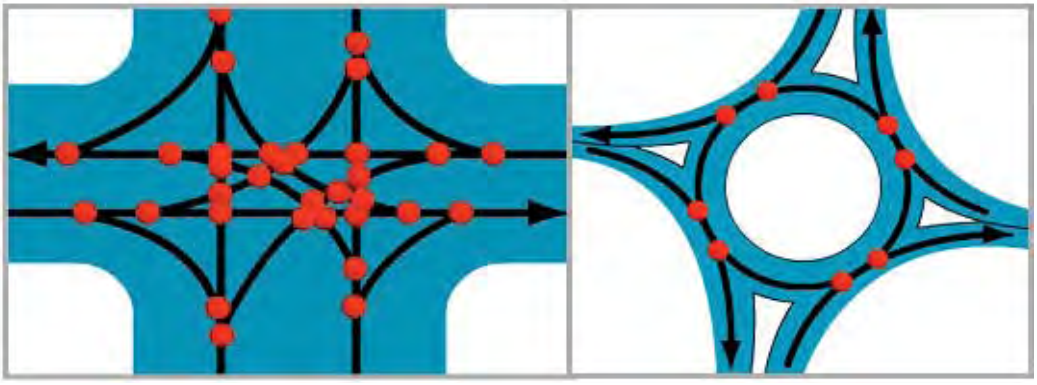
Installing roundabouts in place of traffic signals can also reduce the likelihood of rear-end crashes by reducing abrupt stops at red lights. The vehicle-to-vehicle conflicts that occur at roundabouts generally involve a vehicle merging into the circular roadway, with both vehicles traveling at low speeds — generally less than 25 mph in urban areas.



The reasons for the increased safety level at roundabouts are:

- Roundabouts have fewer conflict points in comparison to conventional intersections. See box below (32 vs. 8)
- Low speeds associated with roundabouts allow users more time to react to potential conflicts and require shorter braking distances.
- Since most road users travel at similar speeds through roundabouts, crash severity is reduced.
- Pedestrians need only cross one direction of traffic at a time at each approach as they traverse roundabouts, as compared with unsignalized intersections. In addition, crossing distances are relatively short, and traffic speeds are lower than at traditional intersections. The conflict locations between vehicles and pedestrians are reduced from 16 to 8 since conflicting vehicles come from a more defined path at roundabouts. With pedestrians have fewer places to check for conflicting vehicles comes less decision making and more safety. In addition, the speeds of motorists entering and exiting a roundabout are reduced with good design.

ROUNDABOUT SAFETY IMPROVEMENT = FEWER CHANCES OF GETTING HIT



On the left, the Red dots indicate 32 Vehicle-to-Vehicle conflict points in a standard four-way intersection. on the right, Red dots indicate 8 Vehicle-to-Vehicle conflict points in a Modern Roundabout.

INCREASED INTERSECTION CAPACITY & EFFICIENCY

Under many traffic conditions, an unsignalized roundabout can operate with less delay to users than traffic signal control or all-way stop control.

Unlike all-way stop intersections, a roundabout does not require a complete stop by all entering vehicles, which reduces both individual delay and delays resulting from vehicle queues. Many drivers adjust their speed to take advantage of approaching gaps in circulating traffic, particularly in the off-peak period. If there is no traffic in the roundabout, they don't have to stop at all.

A roundabout can also operate more efficiently than a signalized intersection because drivers are able to enter from different approaches at the same time when traffic is clear without the delay incurred while waiting for the traffic signal to change (ie no yellow or red times).

Preliminary results from ongoing studies at Kansas State University (KSU) on several modern roundabouts are showing that modern roundabouts have greater overall operational efficiency than all other forms of traffic control. In one example, a KSU study analyzed changes in before and after delay and percent stopping.

Measure of Effectiveness	Before	After	%Diff	Average Operational Performance
Average Intersection Delay (Seconds/Veh)	20	8	-65%	Average vehicle delay for all vehicles entering the intersection
Max Approach Delay (Seconds/Veh)	34	10	-71%	Average vehicle delay for the approach with highest delay
95% Queue Length (Feet)	190	104	-53%	Value below which 95% of all observed lengths of vehicles being backed fall
Proportion Stopped- Intersection (%)	58	29	-52%	Proportion of vehicles approaching intersection and required to stop
Max Prop. Stopped (%)	62	37	-62%	Highest proportion of vehicles stopped on one approach
Degree Of Saturation - Intersection (v/c)	0.463	0.223	-53%	Measure of congestion on the roadway that is being used by traffic

All of this data boils down to less cars stopping, fewer automobiles idling, and more vehicles moving towards their intended destinations. Consider reduction in person-hours of delay and reduced vehicle delay thought the day (not just peak hours)

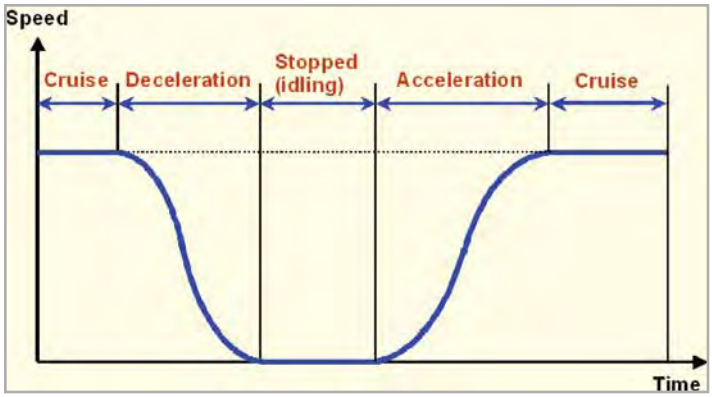
A roundabout serving 15,000 vehicles a day saves, annually, a total of 15,000 gallons of fuel, compared to the same intersection controlled by a traffic light, according to analysis from the Washington State Department of Transportation.

A key finding of the Insurance Institute for Highway Safety in one study is that vehicle delays at the 10 intersections would have been reduced by 62-74 percent, saving 325,000 hours of motorists' time annually. Fuel consumption would have gone down by about 235,000 gallons per year, and there would have been commensurate reductions in vehicle emissions. Assuming $8 per hour in worker wages and $2.50 per gallon of gas is a community cost of $3.1 million. This is equal to giving each City of Lincoln driver a $15 break in wheel tax, or saving the average homeowner of a $150,000 house about $31 annual savings.

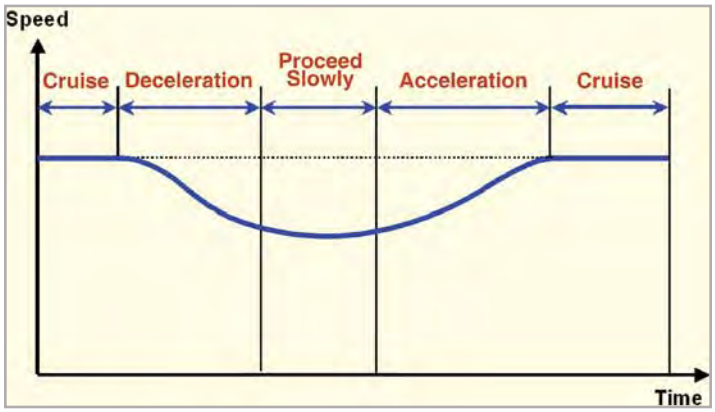
REDUCED ENVIRONMENTAL IMPACTS

By reducing vehicular delay through increased capacity and efficiency, the community will perk up air quality thru lowered emissions.

A typical driving experience will look like the figure below.



With a roundabout the typical driving experience will look like this figure below.



The reduction in Stopped time and acceleration movements means a reduced fuel consumption and increase in air quality. The same KSU study above found in before and after studies, a great amount of reduction in emissions.

Measures of Effectiveness	Before	After	%Diff
Carbon Monoxide (CO) Kg/hr	10.79	7.26	-33%
Carbon dioxide (CO2) Kg/hr	237.30	127.59	-46%
Oxides of Nitrogen (NOx) Kg/hr	0.348	0.225	-35%
Hydrocarbons (HC) Kg/hr	0.446	0.21	-53%

The US Department of Transportation's Congestion Mitigation and Air Quality (CMAQ) Improvement Program provides funding for transportation projects aimed at reducing emissions levels. If a community is in air quality attainment, then those funds may used for any project; if not, then those funds and others are directed to only projects related to bettering the air quality. Roundabouts help the community retain its project choice flexibility.

ENHANCE COMMUNITY VALUES & PROVIDE OTHER COMMUNITY BENEFITS

While each location has specific needs and opportunities, the modern roundabout in certain locations have been used to provide traffic-calming effects, and mark community gateways with enhanced aesthetic opportunities.

Can also be used to help control excessive vehicle speeds (also known as Traffic Calming): Enforcement of vehicle speeds in residential streets is not cost effective using already stretched police forces. A series of roundabouts will provide effective speed control along residential streets by physically reducing all vehicle speeds.

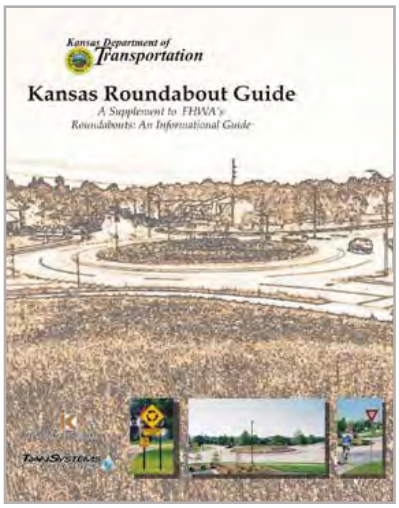
Liability: Traffic signals are a substantial liability for the operating authority. Attorneys often try to prove traffic signals were faulty and therefore the cause of their client's crash. In other words, drivers are not responsible for their behavior because "the traffic signals cause crashes ". At a well-designed roundabout, liability for entry collisions rests with the entering driver: the driver failed to yield to the circulating vehicle.

In the other common type of collision, the rear-end, the following driver is at fault for following too closely. At a multi-lane roundabout a merge type crash responsibility rests with the driver who incorrectly changed lanes.

Note in this photo the large trees saved through the flexibility afford by modern roundabout design that further enhances the community appeal.

One main advantage of modern roundabouts is their considerable geometric flexibility. This enables the efficient connection of difficult roadway alignments.

This geometric flexibility is possible due to the slow approach, entering and exit speeds inherent in properly designed modern roundabouts. Conventional signalized intersections do not have such geometric flexibility as higher vehicle speeds require larger centerline radii.



COST CONSIDERATIONS

Actual cost will depend on project specific conditions. Most agencies find the initial construction cost of a roundabout is comparable to the initial construction cost of a signal. Typically, a roundabout requires fewer turn lanes and possibly fewer through lanes than needed at a signalized intersection, so in some instances a roundabout may actually cost less than a signalized intersection.

A "life-cycle" cost comparison should be used since roundabouts do not require as extensive maintenance efforts. Considering operational and maintenance costs, roundabouts are often less expensive than signals due to reduced costs for signal power, bulb replacement, loop detection, and signal equipment maintenance, including the need to monitor and change signal times. This has been estimated to be $15,000 per year per location. Additionally, communities experience savings in less lost time due to injury crashes, lower insurance rates through safer driving and fewer crash claims, reduced time sitting in traffic, reduction in fuel consumption, and a general increase in motorist satisfaction.

WHAT ARE OTHER DESIGN AGENCIES' POLICIES WITH ROUNDABOUTS?

In addition to many manuals having been written to provide specific guidance, many agencies have written policies regarding making roundabouts an equal option to be considered.

Wisconsin DOT Intersection Control Evaluation Policy

- If an intersection warrants a signal or a four-way stop within the design life of the proposed project, the modern roundabout shall be evaluated as an equal alternative.
- Roundabouts are a potential intersection control strategy until such time that the evaluation indicates that the roundabout alternative is not appropriate.

Virginia DOT Policy

- VDOT recognizes that Roundabouts are frequently able to address safety and operational objectives better than other types of intersections. Therefore, it is VDOT policy that Roundabouts be considered when a project includes reconstruction or constructing new intersections, signalized or unsignalized.
- When the analysis shows that a Roundabout is a feasible Alternative, it should be considered the Department's preferred alternative due to the proven substantial safety and operational benefits.

Georgia DOT Policy

The Georgia Department of Transportation (GDOT) recognizes that the roundabout is a viable intersection alternative when placed in the appropriate location, and designed properly for the local conditions.

Roundabouts are the preferred safety and operational alternative for a wide range of intersections of public roads. A roundabout shall be considered as an alternative in the following instances:

- Any intersection in a project that is being designed as new or is being reconstructed.
- All existing intersections that have been identified as needing major safety or operational improvements.
- All signal requests at intersections (provide justification in the Traffic Engineering Study if a roundabout is not selected).

SO WHY AREN'T MORE ROUNDABOUTS GETTING BUILT?

With all of the benefits of modern roundabouts, why aren't more getting built? The main culprit is public opinion. As described earlier, experience of some drivers with the older circles and rotaries have turned off many, along with a fear of change, myths, rumors, and lack of exposure have all created an atmosphere not conducive for consideration of roundabouts.

What are the FACTS about public opinions? Two studies and opinion surveys have shown that attitudes of the general public before construction of a roundabout improved significantly after exposure to the finished product.

NCHRP SYNTHESIS 264

Attitude towards Roundabouts	BEFORE construction	AFTER construction
Very Negative	23%	0%
Negative	45%	0%
Neutral	18%	27%
Positive	14%	41%
Very Positive	0%	32%

ITE JOURNAL-- SURVEYS IN KS, MD & NV

Attitude towards Roundabouts	BEFORE construction	AFTER construction
Very Negative	41%	15%
Negative	14%	13%
Neutral	14%	9%
Positive	15%	31%
Very Positive	16%	32%

NY STATE SURVEY

Attitude towards Roundabouts	BEFORE construction	AFTER construction
Unfavorable opinion	29%	3%
Moderate opinion	59%	42%
Favorable opinion	12%	55%

"We have had a lot of people not very happy about the idea of roundabouts, but after they are constructed, those fears mostly go away."
-- Brian Walsh, Washington State Dept. of Transportation

These results are mirrored in a general question mailed around the country that found 70% of respondents reported negative feelings before construction and over 70% reported positive after construction.

Richard Retting, a senior transportation engineer and author sends a message for transportation officials: "Just build them (roundabouts). Go ahead and construct a roundabout where it's appropriate, and do it, if possible, when a roadway is first engineered," Retting advises. Especially in suburban areas where population growth and housing development are escalating and new roads are planned, officials would do well to consider roundabouts."

"Don't let initial opposition get in the way," Retting adds. "Many U.S. motorists aren't familiar with roundabouts yet, so they're wary of them. But once the roundabouts are built, the traffic flow and safety benefits turn people around, even people who weren't enthusiastic from the get-go."

QUICK CASE STUDY

Golden, CO – South Golden Road
$1.3 million in 1999 to construct four roundabouts, landscaping, medians & sidewalks

Traffic Volumes
1996 = 11,500 vehicles per day
2004 = 15,500 vehicles per day

Crash History
1997 crash rate = 5.9 crashes / MVM (123 total)
2004 crash rate = 0.2 crashes / MVM (19 total)

Slower Speeds, but a faster overall travel time thru corridor

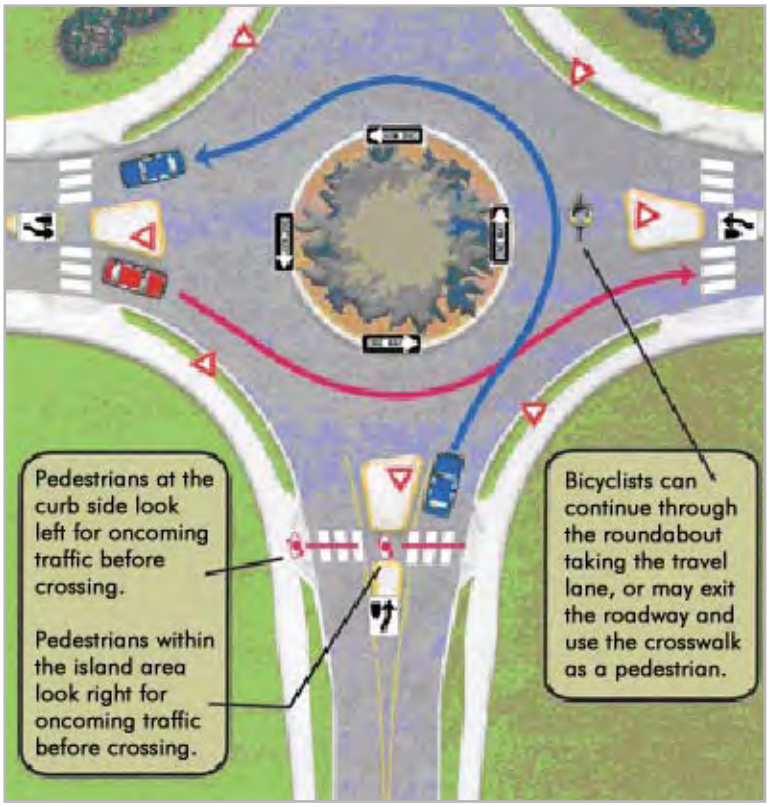
- 47 mph vs. 33 mph
- 103 seconds (stop and go) vs. 68 seconds (more continuous movement)

SUMMARY & CONCLUSIONS

South Golden Road is a typical suburban strip commercial corridor. The installation of four roundabouts within this half-mile long arterial has resulted in slower speeds, but lower travel times and less delay at business access points. Crash rates have dropped by 88% and injury crashes have declined from 31 in the 3 years prior to installation to only 1 in the 4½ years after – a decline in injury crash rates of 93%.

The improvement in traffic flow, vehicular safety and access to businesses combined with amenities such as landscaped medians and pedestrian walkways has stimulated economic activity. Sales tax revenues have increased 60% since installation of the roundabouts and 75,000 square feet of retail/office space has been built. In Golden, CO, businesses have said “Yes, roundabouts are good for business.”

FREQUENTLY ASKED QUESTIONS (FAQs)



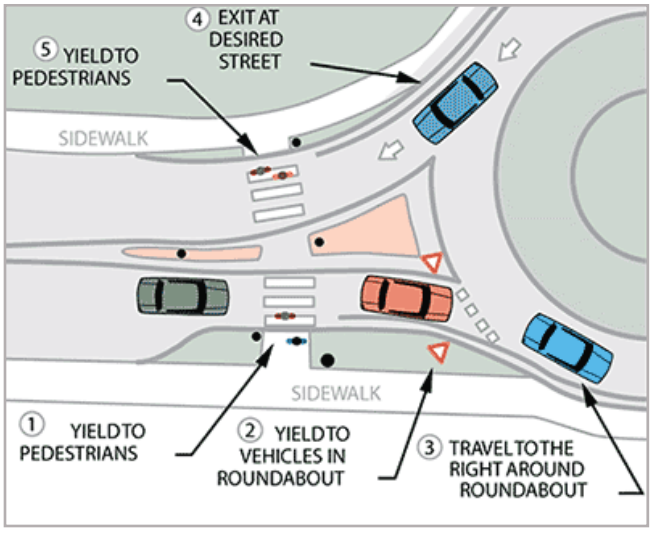
What if you have a big truck go through with a trailer?
Typically smaller trailers require less pavement area to round curves. The roundabouts are designed to accommodate the largest vehicle expected through the intersection.

Why doesn't the City allow the public to vote on how or what type of intersection to have?
Decisions are based on engineering data, safety, cost, and public input. The City has received both positive and negative input for the existing roundabouts.

Aren't these just being used until the City has the money for a traffic signal?
They are not short-term fixes or interim measures to a signal. They are superior to signals and many jurisdictions are removing signals and installing roundabouts.

Is a modern roundabout like a four way stop?
No a modern roundabout is not a 4 way stop. Both intersections are what the engineering community calls a "method of moving traffic". Four way stops require all traffic to stop prior to entering the intersection. Modern Roundabouts require motorists to YIELD at entry ways. All traffic entering a modern roundabout must follow the golden rule of the modern roundabout; Motorists entering a modern roundabout never merge.

Are roundabouts safe for pedestrians?
While it depends on the number of pedestrians and vehicles, in many instances, a modern roundabout can be safer for pedestrians than a traffic signal. This is due to the fact that a pedestrian crossing is reduced to two simple crossings of one way traffic proceeding at relatively slow speeds.



Pedestrian safety is enhanced by the presence of a Pedestrian Crosswalk sign placed right before a vehicle enters a modern roundabout. Even with this precaution, it is recommended that pedestrians use caution and always use the designated crosswalk.

Auto-pedestrian crash rates are usually lower at modern roundabouts than traffic signals Also pedestrian injuries that do occur tend to be less serious thanks to the relatively low speeds demanded by modern roundabouts.

What about visually impaired pedestrians?
Roundabouts may have an advantage to the visually impaired because they only have to address a single direction at one time and they can more easily distinguish between the vehicle noises. Also, slower vehicle speeds are generally safer for pedestrians.

CITY OF LINCOLN GUIDANCE STATEMENT / APPLICATION

Roundabouts are the preferred alternative for a wide range of intersections. Although they may not be appropriate in all circumstances, they should be considered as an alternative for all proposed new intersections. Roundabouts should also be considered for all existing intersections that have been identified as needing major safety or operational improvements. Roundabouts are a potential intersection control strategy until such time that the evaluation indicates that the roundabout alternative is not appropriate. The process of selecting a roundabout as the preferred form of traffic control for a given intersection has three steps. If a roundabout is not "feasible" and/or preferred" at any one of these steps, it will cease to be considered as a viable form of traffic control at the given location.

Step 1: Appropriateness. The initial step involves a "broad brush" determination of whether the site is appropriate for a roundabout. The site specific conditions are to be investigated to determine whether a roundabout merits further consideration.

Step 2: Operational Feasibility. Once a roundabout is determined to be a potentially appropriate form of traffic control, the second step involves testing to determine if a roundabout can function at an acceptable level of service. A capacity analysis is performed to determine volume-to-capacity (v/c) ratio and basic lane needs. This analysis is based on peak-hour volumes appropriate for local conditions. The analysis is conducted for both Construction Year and Design Year traffic volumes.

Important Design Keys to Achieving
ROUNDABOUT SAFETY
- → DEFLECTION
- → LOW SPEED
- → APPROPRIATE LOCATION

Step 3: Comparative Performance. Once it is determined a roundabout can function at an acceptable level of service, the final step compares its performance to the performance of other potential forms of traffic control (such as signalization) at the given location. The comparison may include, but should not necessarily be limited to: operational performance, construction cost, life-cycle cost, right-of-way considerations, "reserve capacity" (the ability to accommodate traffic growth), and constructability.

The justification procedure for each roundabout will be documented in a memorandum describing the results of the analysis identified in the three steps. This memorandum will also summarize the reasons a roundabout was or was not selected as the method of traffic control.

REFERENCE DOCUMENTS & GUIDELINES

FHWA Document: Roundabouts: An Informational Guide (Report No. FHWA-RD-00-067)
http://www.tfhrc.gov/safety/00068.htm

Kansas Roundabout Guide -- A supplement to FHWA's Roundabouts: An Informational Guide
http://www.ksdot.org/burtrafficeng/roundabouts/roundabout_guide/roundaboutGuide.asp

Iowa Department of Transportation Office of Design Modern Roundabouts- General Guidance
http://www.iowadot.gov/design/dmanual/06a-03.pdf

Missouri Department of Transportation – Engineering Policy Guide 233.3 Roundabouts
http://epg.modot.mo.gov/index.php?title=233.3_Roundabouts

Wisconsin's Department of Transportation's Web site dedicated to roundabouts.
https://www.nysdot.gov/main/roundabouts

New York State Department of Transportation's Web site dedicated to modern roundabouts.
https://www.nysdot.gov/main/roundabouts

Kansas State University's Web site dedicated to modern roundabouts
http://www.k-state.edu/roundabouts/

Establishing Right-of-Way Standards for Roundabouts (ITE Article)
http://www.ite.org/traffic/documents/JB09BA24.pdf

Public Rights-of-Way Access Advisory
http://www.fhwa.dot.gov/environment/bikeped/prwaa.htm

Pedestrian Access to Modern Roundabouts: Design and Operational Issues for Pedestrians who are Blind
http://www.access-board.gov/research/roundabouts/bulletin.htm#CROSSING%20AT%20ROUNDABOUTS

NCHRP Project 03-78A, Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities
http://www.trb.org/TRBNet/ProjectDisplay.asp?ProjectID=834

Desktop Reference for Crash Reduction Factors, FHWA-SA-07-015, 2007
http://www.transportation.org/sites/safetymanagement/docs/Desktop%20Reference%20Complete.pdf

Florida Department of Transportation's *Bicycle & Pedestrian Considerations at Roundabouts*
http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_SF/FDOT_824.pdf

Reid Middleton's *Roundabouts: Safety Tips & Guidelines for Drivers, Bicyclists, and Pedestrians*
http://www.reidmiddleton.com/cordata/images/Brochure.pdf