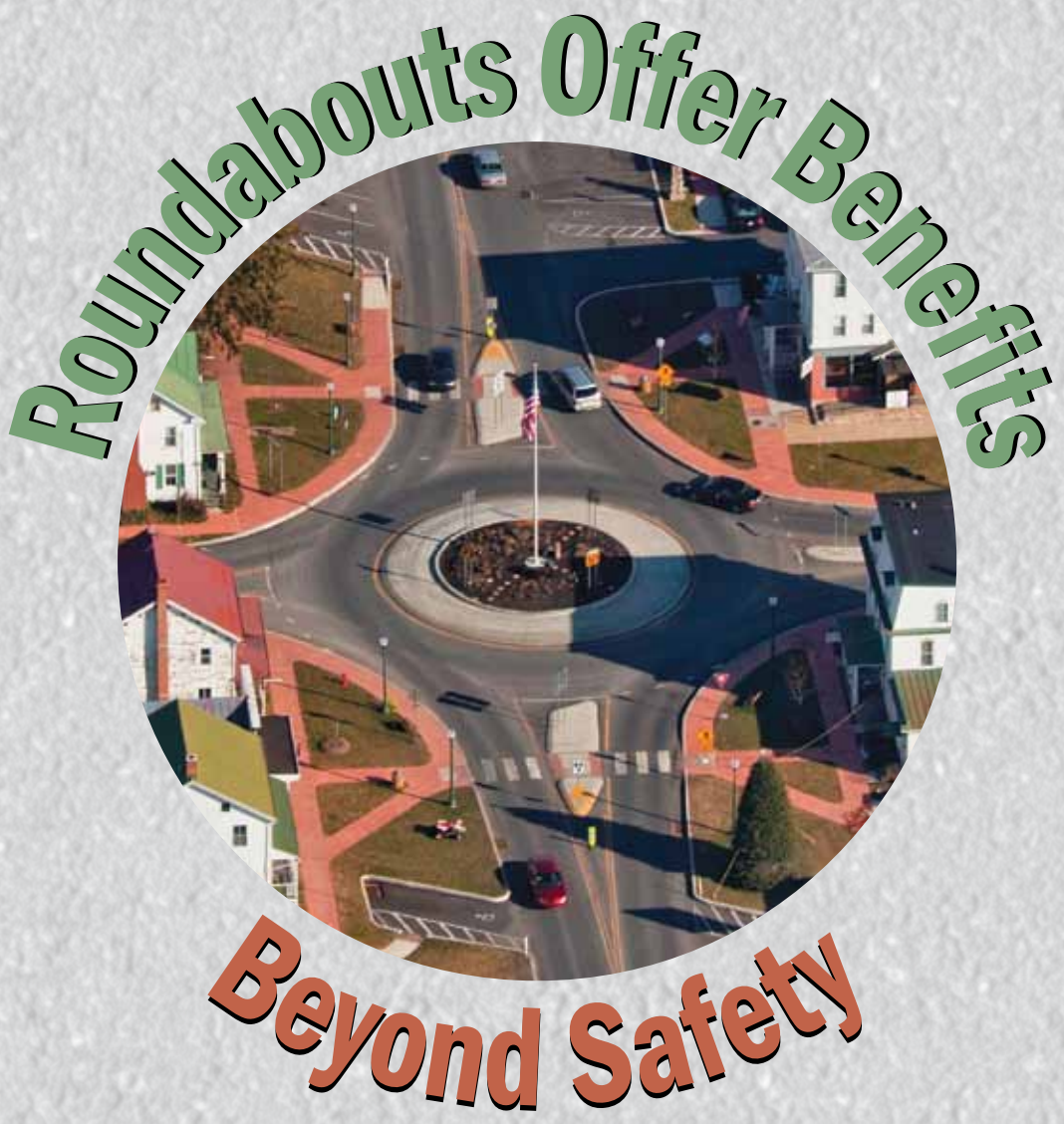

An Old Idea Comes Full Circle with Modern Design

There's no question that roundabouts, those circles that move traffic in one direction around a central island, have their detractors. When designed correctly, however, roundabouts have a lot to offer: increased safety, fewer delays, lower life-cycle costs, decreased environmental impacts, improved aesthetics, and even a greater sense of community.

BY **ANDREW DUERR, P.E.** / GHD SERVICE GROUP MANAGER, ROUNDABOUT SERVICE LINE

Attitudes toward roundabouts vary as widely among townships as they do in the general population. In some townships, such as Lower Paxton in Dauphin County, Cranberry in Butler County, and Washington in Franklin County, officials are enthusiastic about roundabouts. In others, they harbor real concerns and reservations.

These traffic control devices have a long history in Pennsylvania, from the first circular intersections to the modern roundabout. And despite the often-heard misgivings, municipalities — more than any other agency — have reason to advocate for their use. Roundabouts provide opportunities to restore a sense of place in our communities, calm traffic through our villages and neighborhoods, and create safer environments for our residents and businesses — all while moving traffic efficiently, smoothly, and quietly.

A history from squares to circles

The "town square," often referred to as a diamond, plays a storied role in Pennsylvania's history. The Abbottstown diamond, for instance, is one of three along a 14-mile stretch of Route 30 from the York County line to downtown Gettysburg in Adams County. The diamond configuration in Abbottstown predates the 1770s.

John Abbott based the road network and layout of the square in Abbottstown, then known as the Town of Berwick, on a plan that Sir Christopher Wren designed for London, England, following the Great Fire of 1666. Wren's vision consisted of central streets connecting to public squares flanked by a narrow grid of secondary roads and alleys.

The core elements of this vision are still apparent in the aerial view of Abbottstown today. The grid layout that Wren advocated in the 1600s is strikingly similar to a key element of the planning philosophy of New Urbanism, which focuses on walkable, mixed-use communities with dedicated public space. Perhaps this similarity proves the age-old adage that there is nothing new under the sun.

Wide building setbacks and parking in the intersection are common features of Pennsylvania diamonds. By the early 1900s, many communities had placed monuments, flagpoles, parks, and counterclockwise circulation around central islands in their town squares.

For instance, the diamond in Ligonier, Westmoreland County, was converted from a horse corral to a park with a bandstand in 1894. A central island was already in place in the Abbottstown diamond by the early 1900s. And by November 1918, Gettysburg had constructed a circular memorial in the center of Lincoln Square.

As with the rotaries in New England and the large traffic circles of New Jersey and Washington, D.C., town square circles began to fall from favor as increasing traffic and inconsistent rules highlighted the limitations of the circular designs. By the 1950s, many jurisdictions began signalizing the circles

Below is one of two traffic circles in the Village of Linglestown in Lower Paxton Township, Dauphin County, that form Pennsylvania's first roundabout corridor. The corridor, which opened in 2011, also features other traffic-calming and transportation improvement measures.

or replacing them entirely with traffic signals or interchanges. Still, many of Pennsylvania's town square circles survived although they were generally unpopular with the traveling public.

A roundabout revolution

During the 1960s, the British were having similar issues with their circular intersections, or gyratories, as they were often called. Until then, the British generally did not assign priority to any one movement at their circles. Rather, all motorists were expected to exercise "due care" by yielding to each other.

As congestion increased, however, municipalities began experimenting by assigning priority to motorists already in the circle. This allows vehicles to quickly circulate and exit the intersection, creating space for others to enter. Motorists yielding before entering the circle, coupled with low vehicle speeds of those in the roundabout, generate gaps in the flow. Studies by the Road Research Laboratory *(now TRL)* found that this simple change increased capacity by 10 percent, reduced delays by 40 percent, and decreased injury accidents by 40 percent.

The roundabout revolution was born, and they soon spread across England and to the rest of Europe and Australia.

The first roundabout was constructed in the United States in Summerlin, Nevada, in 1990. Since that time, nearly 3,000 roundabouts have been built on state and local roads across the country. The pace has quickened in recent years, especially since the Federal Highway Administration began urging agencies to consider roundabouts as one of its "top nine" life-saving strategies in 2009.

The primary reasons for increased emphasis on roundabouts are their safety and operational performance when compared to other intersection types. Well-designed roundabouts generally decrease the number and severity of crashes while moving traffic more efficiently.

In addition to safety and capacity, FHWA's long list of roundabout benefits includes lower life-cycle costs *(including maintenance and operations)*, improved access management, decreased environmental impacts *(such as better air quality and less noise)*, traffic calming, increased pedestrian safety, aesthetics, land use transitions, and less pavement area.

The first roundabout in Pennsylvania was constructed in 2004 in Richland Township, Bucks County, at the intersection of Station Road and Old Bethlehem Pike — both township-owned roads. The first roundabout corridor, with two roundabouts and other traffic-calming and transportation improvement measures, opened in the Village of Linglestown, in Lower Paxton Township, in 2011.

There are now 20 roundabouts in the commonwealth. PennDOT reports that five more are under construction and at least 16 are in the design phase. Given the emphasis placed on roundabouts by PennDOT and FHWA, townships can expect to see more proposed in the future. We do not, however, have to wait to hear from PennDOT. Indeed, most of the first 20 roundabouts built in Pennsylvania were either municipal-led or involved significant municipal participation.

TOP: Modern roundabouts, such as this one in Lower Paxton Township, Dauphin County, are more compact than older-style circles. The new design reduces traffic speed and discourages oversized vehicles from using those intersections.
BELOW: Vehicles, including a tractor trailer, enter and exit this older and much larger traffic circle in the Borough of New Oxford in Adams County.

But do they work?

It's common to hear the notion of a roundabout rejected because it doesn't seem to work in one place or is being removed somewhere else. "Why would we put one in our township?" supervisors might say. "Roundabouts don't work!"

Roundabouts, however, are *not* traffic circles or rotaries. They share the shape of older-style circular intersections, but there the similarity ends. Several key design features separate roundabouts from the larger and older designs.

First, roundabouts are generally smaller. For instance, the traffic circles in New Jersey were designed large enough to provide room for motorists to merge and weave at 50 mph. The design speed for a typical roundabout is 20 to 25 mph, and a good design avoids merge conditions. The number of lanes and expected vehicle size often play the most significant roles in selecting appropriate diameters for roundabouts.

Second, motorists entering are always required to yield to vehicles already in the roundabout. The right-of-way rules at older traffic circles varied from site to site, creating confusion for motorists. In other locations, stop signs were used in place of yield signs. Yield on entry is a major key to the efficient operation of roundabouts.

Third, good geometric design limits the speed of entering vehicles to 20 to 25 mph for single-lane roundabouts and 25 to 30 mph for larger, multilane roundabouts. Reduced speeds are achieved through the use of relatively tight entry curves and splitter islands on the approach.

Where pedestrians are present, designers should introduce geometric elements to reduce vehicle speeds before crosswalks. Designers should also target lower-speed designs in areas where bicyclists and horses and buggies may use the roundabout. Low-speed design is a key contributor to safety for all users.

Addressing safety concerns

Perhaps the most common assertion from the traveling public is that roundabouts are less safe than signalized intersections. In response, advocates quote statistics suggesting that roundabouts reduce total crashes by 44 percent and severe crashes *(those involving an injury or fatality)* by 82 percent.

Most of the first 20 roundabouts built in Pennsylvania were either municipal-led or involved significant municipal participation.

While these statistics are accurate, it should be noted that most of the intersections that have been converted to roundabouts nationwide were previously controlled by two- or four-way stops, rather than signals.

For more complete data, researchers recently studied the safety record of intersections converted from signals to roundabouts. The Transportation Research Board of the National Academies gathered data from 28 locations across the country that suggests a lower reduction in total crashes *(20 percent vs. 44 percent)* while confirming that the significant reduction in severe crashes *(about 71 percent)* holds true.

A recent study by the Insurance Institute for Highway Safety looked at the safety of two multilane roundabouts on a rural four-lane divided roadway near Bellingham, Washington. While injury crashes fell as predicted, the number of noninjury crashes increased at both locations. A survey revealed "that even after a year, many drivers continued to find the revamped intersections confusing. Nearly half of respondents said it wasn't clear from the signs and pavement markings which lane has the right of way when exiting or that they shouldn't drive next to large trucks in the roundabouts. More than a third said it wasn't clear what speed to drive."

Their findings point to the importance of effective driver education and public

outreach campaigns, along with clear signage and pavement marking design.

Simply looking at statistics ignores the reality that some folks actually feel less safe at roundabouts than they do at traditional intersections. Safety specialists refer to this as "subjective safety." This is in contrast to objective, or statistical, safety, which is based on recorded numbers of crashes and injuries.

Researchers in Norway found that while roundabouts often have a negative effect on subjective safety, or how safe people feel, they have a positive effect on objective, or actual, safety. The study from the Institute of Transport Economics, Norwegian Center for Transport Research, suggests design elements that may improve subjective safety. Examples include installing signalized crosswalks for pedestrians or shared-use paths apart from the road for bicyclists where appropriate — features that have become state-of-the-practice for roundabout design in this country when necessary and feasible.

Tom Vanderbilt, author of the intriguing book *Traffic: Why We Drive the Way We Do (and What It Says About Us)* notes: "There is a simple mantra you can carry about with you in traffic: When a situation feels dangerous to you, it's probably more safe than you know; when a situation feels safe, that is precisely when you should feel on guard. Most crashes, after all, happen on dry roads, on clear, sunny days, to sober drivers."

Bad for business?

Another common concern is that roundabouts have a negative impact on adjacent businesses. One argument is that continuously moving traffic allows less time for passing motorists to observe signs and storefronts. Another is that business will decline because people will avoid the roundabouts.

However, roundabouts have been constructed at major entrances to shopping centers and in the hearts of central business districts. Rather than having an adverse effect, they were integral to the improvements that increased business and fueled economic development and revitalization. Roundabouts are also being incorporated into the internal circulation networks in numerous shopping centers across the country.

South Golden Road in Golden, Colo., is the site of the one of the first roundabout corridors in this country. Before the installation of the roundabouts in 1998 and 1999, the five-lane cross-section was similar to many three- and five-lane roads in suburban and urban Pennsylvania. The corridor was lined with fast-food restaurants, gas stations, and other retail outlets, resulting in numerous unorganized access points on both sides of the road. Pedestrians had to cross 84 feet of road to go from one side to the other.

The city installed four roundabouts along a ¾-mile section and replaced the five-lane section with four lanes and a raised median. According to the city, the typical vehicle speed dropped from 47 mph to 33 mph, while the travel time through the corridor dropped from 103 seconds to 68 seconds — a 34 percent time savings.

In the six years after the initial construction, the city saw an 85 percent reduction in total crashes and a 96 percent reduction in injury crashes despite the fact that traffic volumes increased by 35 percent. In addition to the impressive safety and operational gains, businesses have seen a 60 percent increase in sales, attracting additional retail and office development along the corridor.

In Pennsylvania, Lower Paxton Township and PennDOT completed the construction of roundabouts on both ends of the Village of Linglestown in 2011. The village had become dissected by a busy arterial road that carried approximately 14,000 vehicles per day, and residents no longer felt it was safe for their children to walk to school. The roundabouts were installed as part of a larger streetscape and traffic calming project intended to enhance the safety and security of the residents while preserving the village's character and quality of life.

Geof Smith, owner of St. Thomas Roasters in the village, says that his business picked up following the construction.

"Backups no longer occur in town, and access to the business is much easier now," he says. "Business was hurt during the extended construction, but that was expected given the extensive streetscape and utility work completed as part of the project. Without the grid layout of the village, which allowed access from behind the building while Route 39 was under construction, my business would have been hurt even more."

George Wolfe, Lower Paxton Township manager, notes several other benefits.

Roundabouts provide opportunities to **restore a sense of place** in our communities, **calm traffic** through our villages and neighborhoods, and **create safer environments** for our residents and businesses — all while **moving vehicular traffic efficiently, smoothly, and quietly.**

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"The roundabouts and streetscape have generally resulted in lower speeds through the village," he says. "Traffic used to back up through the village during the morning rush hour, and that no longer happens. Queues tend to disperse very quickly."

Walking and biking in roundabouts

Safety, especially at multilane roundabouts, is often a concern for pedestrians and bicyclists, who believe they won't be able to find gaps in the traffic flow. While recent studies have found that motorists' yield rates at roundabouts appear to be lower than desired in many parts of the country, other studies have found that the time required for a pedestrian to cross the street is often lower at roundabouts than at other types of intersections.

This suggests that adequate gaps do exist. To get motorists to yield at roundabout crosswalks, several jurisdictions have begun education and enforcement campaigns. The fact is that yielding rates in many parts of the country are low at all types of intersections. Aggressive driving is a problem that needs to be addressed across the board.

Pedestrians with visual impairments may have difficulty traversing roundabouts, which do not offer the audible cues provided at signal-controlled intersections. Sound from circulating vehicles often masks the sound of vehicles exiting the roundabout. The nonyielding behavior discussed above is even more important to the visually impaired because it may reduce the accessibility of the crossing.

The U.S. Access Board, a federal agency that promotes equality for people with disabilities through accessible design, is developing rules to help visually impaired pedestrians locate and navigate roundabout crossings.

Advocates of roundabouts have historically pointed to international studies and several design features to support claims that roundabouts are safe for pedestrians and bicyclists. Recent U.S. research also supports this position. However, the sample sets used in the study were small, and more research is required. The international safety data for bicyclists is mixed: Data from Britain shows more bicycle-related crashes in roundabouts than at signalized intersections, data from France suggests fewer but more severe crashes at roundabouts, and Australian data shows lower bicycle crash totals and severities at roundabouts.

Design elements that promote pedestrian and bicycle safety include geometry that forces speed reduction to 15 to 25 mph in and around the intersection, splitter islands on the approaches that afford pedestrians a refuge between opposing traffic flows, and shorter overall crossing distances. Basic physics also supports the safety claim. According to the Federal Highway Administration, "more than 80 percent of pedestrians hit by vehicles traveling at 40 mph or faster will die, while less than 10 percent will die when hit at 20 mph or less."

The same design elements that contribute to bicycle safety also translate to horse and buggy traffic. An Old Order Mennonite community in Berks County recently embraced a roundabout concept because they recognized that the roundabout would reduce vehicle speeds to 20 to 25 mph — much closer to the speeds that buggies travel.

Assessing the cost

A final criticism of roundabouts is that they cost more than traffic signals to install. The initial construction cost can be higher for roundabouts, especially if the traffic signal installation requires only limited modifications *(with no additional turn lanes, for example)*. Also, the larger footprint of a roundabout often requires more right-of-way area at the intersection than other alternatives. However, dismissing roundabouts based on the initial construction cost or right-of-way requirements overlooks several opportunities that may be attractive to townships.

First, initial construction cost is only one element of the life-cycle cost of the intersection. Long-term maintenance, fuel costs, time lost due to traffic congestion, and the cost of crashes *(especially injury and fatal crashes)* should also be factored into any benefit/cost analysis when evaluating alternatives.

A developer may prefer to install a signalized intersection, presumably because of lower upfront costs, but the township and its taxpayers will be left to maintain the signals into the future. FHWA estimates an average annual maintenance cost of $5,000 per signal per year. This includes hardware, maintenance, and electrical costs, as well as

Counting the Cost of Crashes

Vehicle crashes take their toll in many ways, and one of those is economic. The U.S. Department of Transportation has published the following estimates of the value of preventing injuries:

Injury Severity	Estimated Value (2014)
Fatality	$5,300,000
Critical	$3,150,000
Severe	$1,400,000
Serious	$560,000
Moderate	$250,000
Minor	$160,000

the engineering costs associated with occasional signal retiming.

Roundabouts do require landscaping and electricity for street lighting, but townships have the option of asking civic groups to maintain plantings in the central island. A second option is to install low-maintenance landscaping, but this may reduce the roundabout's potential to improve the aesthetics along the corridor and could minimize the positive impact as a gateway to the community.

Likewise, focusing on right-of-way requirements at the intersection misses a larger benefit of roundabouts, especially when this option is used in tandem along a corridor. As traffic increases on a typical road, the intersections become bottlenecks, and left turns to and from entrances become increasingly difficult. Lanes, such as a two-way left-turn lane, are added to improve access management or increase the capacity at the intersections.

This current practice might be referred to as "wide roads and narrow nodes *(intersections)*." Roundabouts offer a shift from this mindset by increasing the throughput at the intersection. This often allows for fewer lanes between intersections and decreases the right-of-way impacts along the entire corridor, making for "wide nodes and narrow roads," a phrase coined by engineer Leif Ourston in the late 1980s.

The "wide nodes" approach can be very effective for townships wishing to retain the historic, and narrow, nature of its existing roads or to implement road diets and other initiatives to downsize wide roads.

Until recently, the costs that traffic accidents represent to society have been difficult to estimate. With the release of FHWA's "Highway Safety Manual" in 2010, agencies and designers can now predict the safety benefits in terms of crash reduction resulting from various improvements. By multiplying the crash reduction potential of an alternative by the average costs per injury severity, we can estimate the dollar value of safety benefits.

As shown in the table on the opposite page, the U.S. Department of Transportation estimates the economic impact of a fatal accident to be approximately $5.3 million in 2014 dollars. Given the demonstrated safety benefit of roundabouts, most notably in terms of reducing crashes involving injuries and fatalities, the benefit-to-cost ratios for roundabouts can be well above those for signalized intersections, especially intersections with a significant crash history.

And finally, it is interesting to consider the cost of congestion, both in terms of time lost and fuel wasted while vehicles idle at congested intersections. In 2005, the Insurance Institute for Highway Safety compared such figures for 10 intersections in Virginia where signals were recently installed or upgraded with the predicted performance if roundabouts had been installed instead.

The resulting report estimated "that roundabouts would have reduced vehicle delays by 62 to 74 percent, depending on the intersection, thus eliminating more

TIPS: Agencies offer guidance on roundabouts

PennDOT recommends that when townships plan intersection improvements, they evaluate a variety of alternatives, including roundabouts, to determine the most appropriate option.

The **Federal Highway Administration** recommends considering roundabouts in the following situations:

- as an alternative for intersections on federally funded highway projects that involve new construction or reconstruction;
- when rehabilitating existing intersections that need major safety or operational improvements; and
- at highway interchange ramp terminals and rural high-speed intersections.

than 300,000 hours of vehicle delay on an annual basis. Annual fuel consumption would have been reduced by more than 200,000 gallons, with commensurate reductions in vehicle emissions." Assuming an average cost per hour of delay at $12 *(based on data from the U.S. Department of Transportation)* and an average fuel cost of $3.25 per gallon, both conservative estimates, the findings represent an average cost to the traveling public of $425,000 per year per intersection.

Connecting to the past, planning for the future

Clearly, townships have a vested interest in expanding the use of roundabouts. In many cases, when all of the costs and benefits are accounted for over the life cycle of an intersection, the cost of *not* choosing a roundabout can be significant for the township, its residents, and the commuters and businesses that use and depend on the local roads.

Many concerns about roundabouts, especially those with multiple lanes, are understandable and point to the need for good design. Beyond the benefits of cost and safety, roundabouts represent a connection to our past and opportunities to re-establish our communities as the destinations that they are, rather than just groupings of houses and businesses along a busy route. Roundabouts also enhance travel by decreasing commute times and help businesses prosper with safer and easier access.

Roundabouts will not be the appropriate solution at many locations due to a variety of constraints and considerations. However, given the sheer number of existing and potential signalized intersections on Pennsylvania roads, imagine the benefit if only 10 or 20 percent of these intersections were converted to roundabouts in the coming years. ✦