Mini-Roundabouts for the United States

THIS FEATURE EXAMINES THE HISTORY, SUCCESS AND SOME FAILURES OF MINI-ROUNDABOUTS IN THE UNITED KINGDOM. THE MAIN PRINCIPLES REGARDING DESIGN, SAFETY AND GENERAL OPERATION ARE DISCUSSED FOR THEIR POTENTIAL APPLICATION IN THE UNITED STATES. THE BASIS FOR SITE SELECTION IS CLARIFIED, INCLUDING SINGLE AND MULTIPLE USE OF MINI- OR SMALL ROUNDABOUTS IN SMALL NETWORKS. EFFECTS ON VULNERABLE USERS ARE ALSO CONSIDERED.

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INTRODUCTION

Many Americans have been fascinated by the United Kingdom's large numbers of modern roundabouts, particularly mini-roundabouts. Americans have often found them difficult to drive because they are not used to living with roundabouts. What are mini-roundabouts? Why might their development apply to the United States?

A mini-roundabout may be considered at an intersection where the available right of way is not sufficient to install a normal roundabout with a solid central island.

A mini-roundabout is a small form of modern roundabout that is fully overrunnable, where all traffic should yield on entry to vehicles circulating around it. On entering the circulation, all vehicles must pass to the correct side of the central island unless they physically cannot do so, when the trailing part of the vehicle may pass over and to the "wrong" side of the central island.

A mini-roundabout is the same as a modern roundabout but there is no solid central island, only a truck apron. The only other difference is the scale of the intersection; the inscribed circle is less than around 28 meters (90 feet). Otherwise the operational characteristics are much the same as a normal modern roundabout with a central island. This is dependent upon making the truck apron—now a stand-alone device—work properly. That is where problems have arisen in the United Kingdom because the overrunnable island is limited to a 4-meter diameter.

BRIEF HISTORY OF ROUNDABOUTS IN THE UNITED KINGDOM

The United Kingdom developed roundabouts in the 1960s and 1970s. The yield-on-entry rule was widely tested and proven over the period from 1962 to 1966. Roundabouts could become smaller because they were no longer locked up. Tests in 1971 showed that large roundabout layouts did not work well even with the yield rule. Further tests on smaller three-arm roundabouts proved that the mini-roundabout with its nominal central island would work at appropriate sites and would yield much higher capacity than equivalent traffic signals.

Mini-roundabouts proved easy and inexpensive to install. They reduced the numbers and severity of crashes and had a good local speed reduction effect. They replaced "priority" junctions effectively, particularly where these tended to become knotted up. In the United States, many all-way stop intersections do not perform well. These represent opportunities for mini-roundabout retrofits.

BACKGROUND IN THE UNITED STATES

Historically, there are many circular intersections of various sizes in the United States and Canada. Commonly known as traffic circles, those with small solid islands in residential road intersections operate well for their intended purpose, i.e., to allow turning movements at slow speeds. Their larger relations—rotaries—have become notorious. They operate too fast and have poor capacity and a poor crash rate.

For these and other reasons, the modern roundabout, with its very different actual operation but its apparent similarity to traffic circles, is viewed with skepticism in the United States. It is only a matter of time before sufficiently well-designed modern roundabouts confirm the benefits that are so different from the rotaries that preceded them. Compared with traffic signals, roundabouts can operate with much reduced delay, particularly during off-peak periods. It is mostly at all-way stop and yield intersections that small and mini-roundabouts will find their niche over the next 25 years. Correctly installed, they will represent efficient, safe and low maintenance features for many years to come.

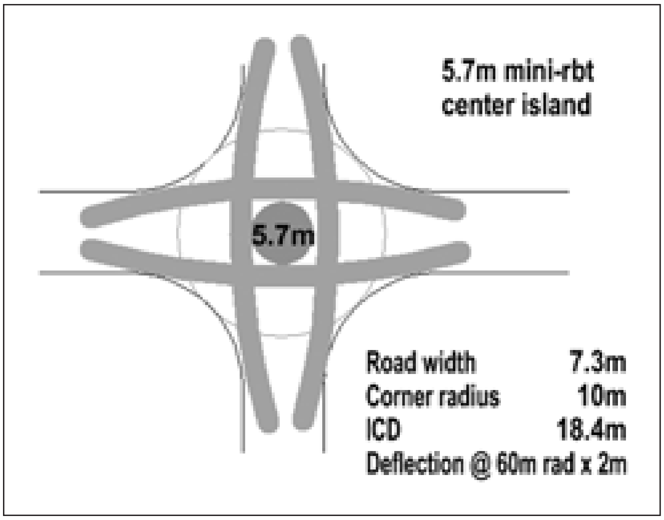


Figure 1. Illustration of deflection required at crossroad sites.

Figure 2. A mini-roundabout at a crossroad in the United Kingdom. This site features a 6-meter diameter domed roundabout; there have been two slight injury accidents in the 20 years since installation.

THE DESIGN OF MINI-ROUNDABOUTS

Layout Characteristics

When working with normal modern roundabouts, vehicle paths are largely dictated by the central island and splitter islands. At mini-roundabouts, this is a precise science. The layout must be devised in accordance with desired vehicle paths. Key issues are:

- getting drivers to circulate around the central (now overrunnable) island; and
- forcing a deflected path for the movements that cross one another's paths—"left" turns.

Safety studies in the United Kingdom indicate that most crashes at mini-roundabouts involve a failure to deflect these crossing movements sufficiently. Figure 1 illustrates the principle in the easiest situation to recognize—the crossroad. It features an idealized layout to illustrate the principle. Left-turning vehicles are heavily curved; the danger comes from the through movements if the central island is too small, which is a serious problem in the United Kingdom because the island is legally restricted to a 4-meter diameter (see Figure 2).

Figure 3 illustrates a site where the central island has been made large enough to deflect the through movements. The author recommends splitter islands on the approaches. These may be overrunnable or curbed. The latter should include a sign requiring drivers to keep right. Internally illuminated bollards (lit from beneath) can be most effective and are virtually indestructible. All vehicles must attempt to circulate in a counter-clockwise direction around the center, allowing if necessary the trailing parts of a long vehicle to overrun the island.

Three-Arm Mini-Roundabouts

These are the most common roundabouts in the United Kingdom and mostly work well, resolving the problems of side roads where turning left onto the priority streams can be difficult, especially where there is a stack lane for the left-turn queue to turn left into the side road. The geometry varies and may be symmetrical or Y-shaped, T-shaped, or left or right splay. T and splay layouts can present problems of overshooting. Deflection must be applied to the crossing stream, the one that cuts across the paths of the other two left-turning movements. The stream that follows the curb may be deflected, but it is difficult to do this effectively without making matters worse. There are many U.K. examples of various curb build-outs along a straight curbline;

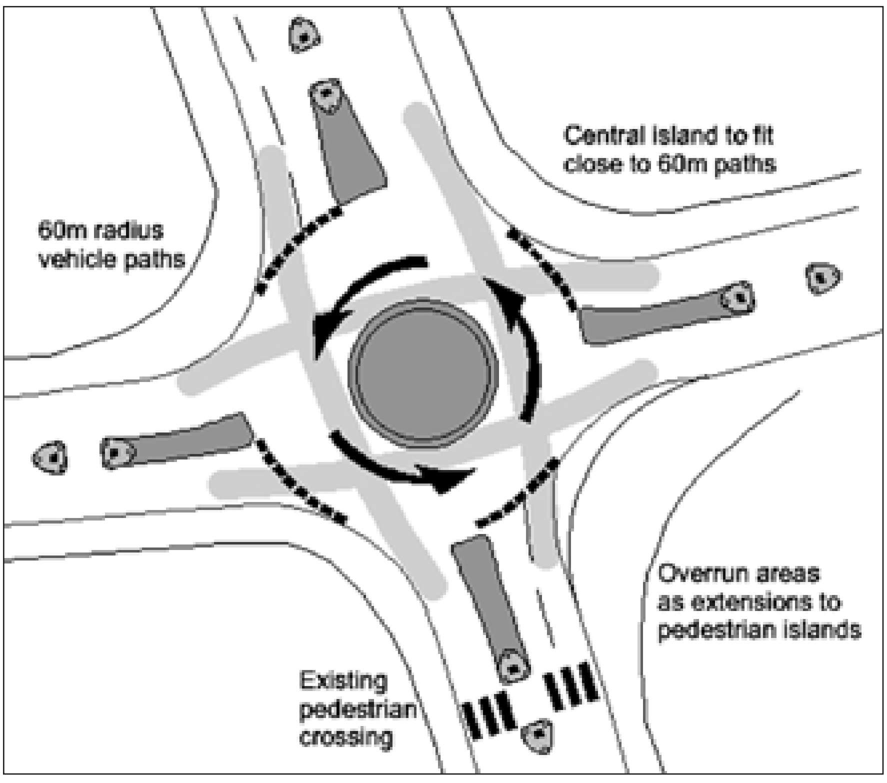


Figure 3. Plan of a large island mini-roundabout to illustrate the principle at a real site.

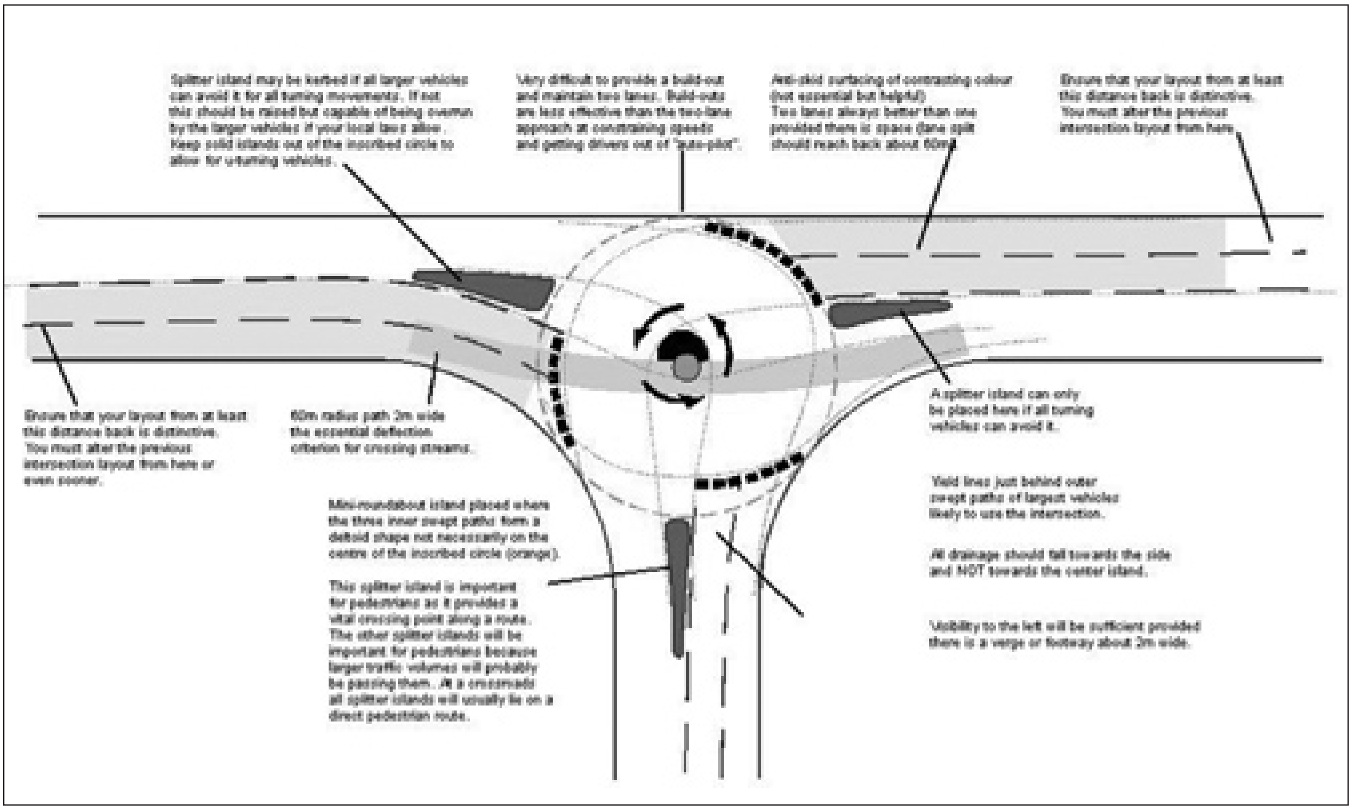


Figure 4. The typical design of a mini-roundabout at a large T-intersection.

however, most are ineffective and can cause crashes. Figure 4 illustrates the method of laying out a larger T-shape mini-roundabout to provide optimum performance.

Central Island Geometry

Observation shows that central islands in the United Kingdom often fail to deflect drivers sufficiently. They may be raised but conventionally are mostly flush or so gently profiled that there is virtually no deterrent against overrunning by many drivers. They should therefore be constructed equivalent to a truck apron. In the United Kingdom, their side slope may not be steeper than 1:4, or approximately 15 degrees. U.S. rules may allow steeper edges. Whatever the case, the author recommends that all mini-roundabout centers be nearly flat-topped with distinct side slopes at around 1:4. The overall height is not critical but should not be less than 50 millimeters (2 inches), preferably 3 inches. Always drain away from this island.

Splitter Islands

Splitter islands may be curbed or overrunnable. Curbed islands are preferred because they will always be used by pedestrians as a means of crossing the intersection one stream at a time. The splitter island guides entering drivers along the correct path; no part of the splitter island should lie within the inscribed circle. While it is a useful location for traffic signs, it is important not to clutter it because this might obscure the layout beyond.

Safety of Mini-Roundabouts

Mini-roundabouts in the United Kingdom represented a novelty of highway invention; the public was curious about them and, understandably, there was much skepticism. In the early days of experimenting with center islands of reduced sizes, two key issues arose:

1. reducing the diameter of existing roundabouts caused an increase in numbers of accidents; and
2. introducing small or mini-roundabouts at a non-roundabout site reduced numbers and severity of accidents.

A particular experimental site showed an increased risk when reducing the central island from the normal U.K. size to an 8-meter diameter. Several traffic movements across the intersection were able to take place in a straight line and traffic tended to get knotted in the central area. Early results showed that the benefit of "pealing" a large roundabout occurred mostly for the first few meters from the diameter; thereafter further reductions of the central island yielded little capacity benefit and, worse, opened straight paths leading to increased accident risk. It was learned that the central island is important in ensuring adequate deflection for all streams that enter a roundabout crossing the paths of other streams.

A second lesson from the experimental site indicated safer general operation of all modern roundabout forms compared with other intersection controls regardless of size. Roundabout operation has proven to be fundamentally safer than other forms of intersection control provided the roundabout provision is justified in the first place and correctly designed.

TRAFFIC CONFIGURATION

Early experimental mini-roundabout sites came about as a result of a trawl by the U.K. Transport Research Laboratory, which was seeking sites where experiments could be carried out on the public highway. Sites came forward that had a poor record of congestion, crashes and general dysfunction. These made excellent mini-roundabouts, and most remain in place today.

A key factor in their operation was the traffic levels, in particular their turning movements. There was usually sufficient flow to make the right turns (U.S. left turns) at these sites so that all drivers approaching the site quickly realized that they would have to be prepared to yield on entry, similar to a normal roundabout. Equivalent sites in the United States would appear to be all-way stop sites that have become too congested to operate properly. A warrant is recommended for (mini-) roundabout introduction based on various factors including traffic demand.

Geometric Aspects

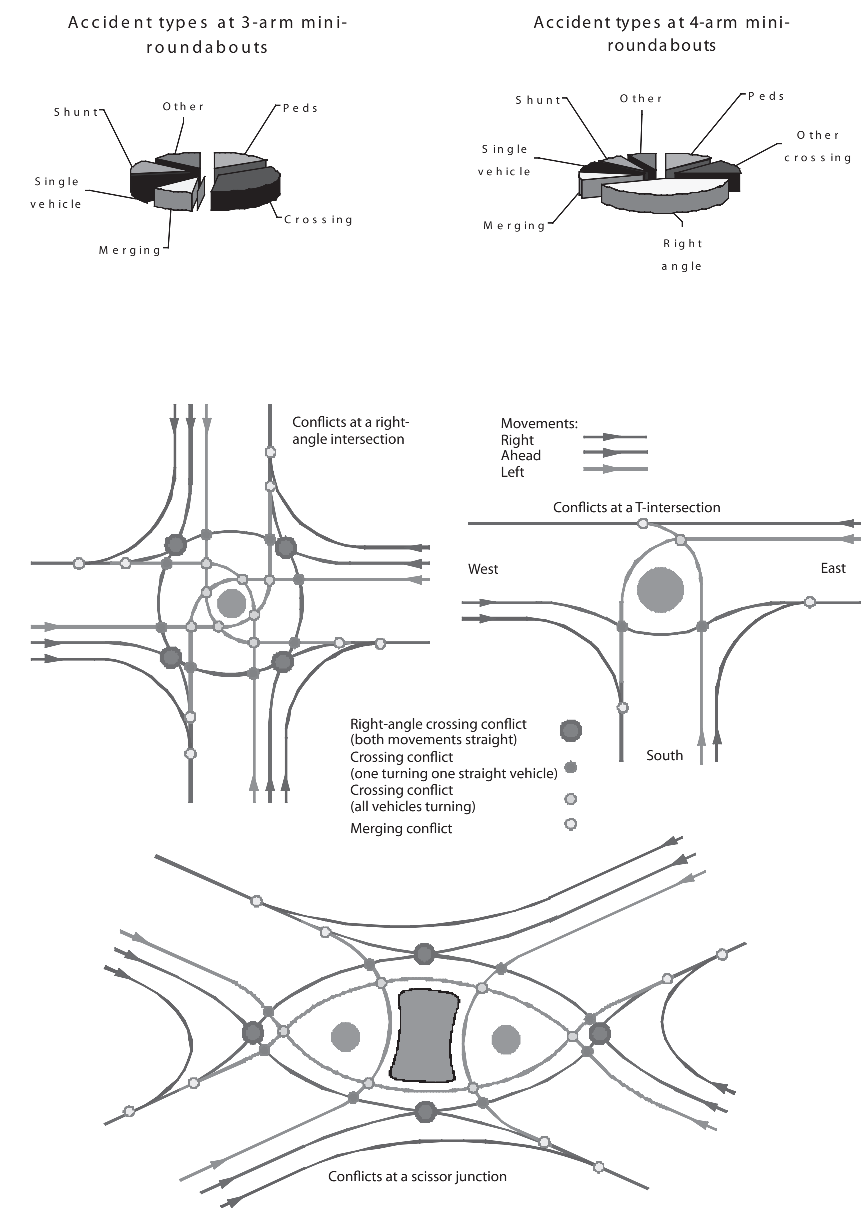
Figure 1 made reference to conflicts at crossroads and the need to deflect crossing streams. Figure 5 illustrates the various conflicts at three- and four-arm mini-roundabouts of specific configuration: a) the T-intersection; b) the right-angle crossroad; and c) the oblique crossroad configured as a double mini-roundabout. Contrary to some documentation, these drawings illustrate the full array of conflicts that potentially arise at these forms or mini-roundabouts and how they relate to the crash types in the two pie charts.

The various conflict points are mostly made safe by control of speed, but the stream following a straight curb (in effect turning right) can be difficult to slow down by geometry alone. Any alteration of the curbline needs to be substantial to have any actual effect on speeds and often ends up compromising the layout altogether. The approach layout needs to look different and use relatively narrow lanes that squeeze light vehicles while at the same time providing good space for bicyclists. Although this has not found much favor in the United Kingdom, the accident record at the sites where this was done was found to be good. Typically around 8 percent of crashes at mini-roundabouts involved this merging movement; sites with these features on the straight approaches tended not to suffer merging accidents.

Vulnerable Users—Pedestrians and Cyclists

Pedestrians may not find crossing at roundabouts easy, but they have the benefit of splitter islands so they can cross one direction of flow at a time. In most cases at mini-roundabouts this is only a single lane. Occasionally there may be two narrow lanes entering the site. Crossing the road requires caution, but the task is not difficult for able pedestrians, and studies have indicated lower crossing times and relatively few pedestrian accidents at all roundabouts.

Bicycle accidents at larger roundabouts in the United Kingdom have been a cause for concern. International observers report that the United Kingdom tolerates higher speeds across its roundabouts than other countries. In the United Kingdom, the presumption has been made that roundabouts have to favor circulating traffic and, therefore, all U.K. roundabouts (except most mini-roundabouts) are drained toward the center. Only very few local small roundabouts are drained outward; this has occurred at retrofits, for example, at



These diagrams relate to the two pie charts at the top. It can be clearly seen that the vehicle paths through the crossing conflict points must be suitably controlled. For a single mini-roundabout at a crossroad, that usually means a sufficiently large center island.

Figure 5. Geometric accidents and conflicts in the United Kingdom.

clock towers where to remove material to create inward drainage may endanger the feature that the roundabout was designed to protect.

As a result of higher speeds, cyclists have found roundabouts to be hostile environments. Attempts to create bicycle paths around the periphery (along the circumference of the inscribed circle) have placed bicycles where least expected by drivers and mostly have not worked. A crash that would have involved property damage between cars would usually result in injury to a bicyclist.

At mini-roundabouts the situation is somewhat better, but all two-wheelers remain vulnerable at mini-roundabouts, mostly where deflection has not been adequately provided. The two-wheeled casualty has usually been the one with priority while the other vehicle has usually failed to yield. However, this does not mean bicyclists are in grave danger at mini-roundabouts. Correctly designed schemes have casualty rates among two-wheeled machines that are no higher than other forms of control.

SELECTION OF SITES

Y-Intersection

The Y-intersection is the simplest geometric configuration for a mini-roundabout. The geometry lends itself to the layout, and all drivers have to negotiate a degree of physical curvature that enforces low speed. This scheme works well with a reasonable level of turning traffic.

T-Shape

The majority of U.K. mini-roundabouts are configured in layouts that are or were T-shaped. The decision to proceed will depend on the current and future levels of traffic. As flows rise, the side-road layout begins to fail with queues forming and waiting to turn left onto the priority route. This is further complicated if a queue develops to turn left into the side road. These "knotty" situations are exactly where mini-roundabouts work best. This is often backed up by a developing crash pattern at the site, which is further justification for change. If the road on the stem of the T carries less than approximately 10 percent of the total flows, this will probably not make a good mini-roundabout.

IN THE UNITED STATES, MANY ALL-WAY STOP INTERSECTIONS DO NOT PERFORM WELL. THESE REPRESENT OPPORTUNITIES FOR MINI-ROUNDABOUT RETROFITS.

The Crossroad

Although more difficult in some respects (the six turning movements at a T-layout become 12 at a crossroad), traffic design and operations professionals will quickly spot intersections that start to lock up. Perhaps there will be an all-way stop layout that is failing. There could be a developing crash pattern pointing to a needed improvement. The essential issue is that there must be sufficient traffic movement to make the circulatory aspect work (the 90-percent rule above).

Multiple (Mini-) Roundabouts

If the crossroad is staggered or scissored (see Figure 5) with two clearly identifiable centers, two mini-roundabouts should be considered. In the "before" situation, these intersections may be locking up badly between one another. The new layout will probably clear this and reduce the crash pattern. Queues rarely form between the two mini-roundabouts. The overall speed reduction and additional splitter islands will also greatly assist pedestrians crossing the road nearby (see Figure 5).

The other special case for small or mini-roundabouts in a network may well be the retrofit of a large rotary or one-way system. Some extraordinary networks have been derived from large roundabouts in the United Kingdom retrofitted with a series of small or mini-roundabouts at the entry nodes. The layout then becomes a ring network. There are not many in the United Kingdom, but they all work reasonably well. There are several hybrid schemes where signals are used at the nodes where a roundabout cannot be used, for example where an arm is one-way such as a slip-road.

CONCLUSIONS

This author believes that the mini-roundabout will make a substantial appearance in the United States soon, alongside larger modern roundabouts in the next 25 years. Their use and appropriate detailed design will determine their success. The proliferation of them in the United Kingdom is testimony to their general success and acceptance. ■

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