

Glossary

85th-percentile speed—a speed value obtained from a set of field-measured speeds where only 15 percent of the observed speeds are greater (source: HCM 2000).

AADT—see *average annual daily traffic*.

AASHO—American Association of State Highway Officials. Predecessor to *AASHTO*.

AASHTO—American Association of State Highway and Transportation Officials.

accessible—describes a site, building, facility, or portion thereof that complies with the Americans with Disabilities Act Accessibility Guidelines (source: ADAAG).

accessible route—a continuous, unobstructed path connecting all accessible elements and spaces of a building or facility. Exterior accessible routes may include parking access aisles, curb ramps, crosswalks at vehicular ways, walks, ramps, and lifts (source: ADAAG).

accident—see *crash*.

ADA—Americans with Disabilities Act.

ADAAG—Americans with Disabilities Act Accessibility Guidelines.

all-way stop control—all approaches at the intersections have stop signs where all drivers must come to a complete stop. The decision to proceed is based in part on the rules of the road, which suggest that the driver on the right has the right-of-way, and also on the traffic conditions of the other approaches (source: HCM 2000).

angle, entry—see *entry angle*.

approach—the portion of a roadway leading into a *roundabout*.

approach capacity—the capacity provided at the *yield line* during a specified period of time.

approach curvature—a series of progressively sharper curves used on an *approach* to slow traffic to a safe speed prior to reaching the *yield line*.

approach road half-width—term used in the United Kingdom regression models. The approach half width is measured at a point in the approach upstream from any *entry flare*, from the median line or median curb to the nearside curb along a line perpendicular to the curb. See also *approach width*. (source: UK Geometric Design of Roundabouts)

approach speed—the posted or 85th-percentile speed on an *approach* prior to any geometric or signing treatments designed to slow speeds.

approach width—the width of the roadway used by approaching traffic upstream of any changes in width associated with the roundabout. The *approach* width is typically no more than half the total roadway width.

apron—the mountable portion of the *central island* adjacent to the *circulatory roadway*. Used in smaller roundabouts to accommodate the wheel tracking of large vehicles.

average annual daily traffic—the total volume passing a point or segment of a highway facility in both directions for one year divided by the number of days in the year (source: HCM 2000).

average effective flare length—term used in the United Kingdom regression models. Defined by a geometric construct and is approximately equivalent to the length of flare that can be effectively used by vehicles. (source: UK Geometric Design of Roundabouts)

AWSC—see *all-way stop control*.

back of queue—the distance between the yield line of a roundabout and the farthest reach of an upstream queue, expressed as a number of vehicles. The vehicles previously stopped at the front of the queue may be moving (adapted from HCM 2000).

A

B

benefit-cost analysis—a method of economic evaluation that uses the *benefit-cost ratio* as the measure of effectiveness.

benefit-cost ratio—the difference in benefits between an alternative and the no-build scenario, divided by the difference in costs between the alternative and the no-build scenario. See also *incremental benefit-cost ratio*.

bulb-out—see *curb extension*.

C capacity—the maximum sustainable flow rate at which persons or vehicles can be reasonably expected to traverse a point or uniform segment of a lane or roadway during a specified time period under a given roadway, geometric, traffic, environmental, and control conditions. Usually expressed as vehicles per hour, passenger cars per hour, or persons per hour (source: HCM 2000).

capacity, approach—see *approach capacity*.

capacity, roundabout—see *roundabout capacity*.

capital recovery factor—a factor that converts a present value cost into an annualized cost over a period of n years using an assumed discount rate of i percent.

central island—the raised area in the center of a *roundabout* around which traffic circulates.

CFR—Code of Federal Regulations.

channelization—the separation or regulation of conflicting traffic movements into definite paths of travel by traffic islands or pavement marking to facilitate the safe and orderly movements of both vehicles and pedestrians (source: 1994 AASHTO Green Book).

circle, inscribed—see *inscribed circle*.

circular intersection—an intersection that vehicles traverse by circulating around a *central island*.

circulating flow—see *circulating volume*.

circulating path radius—the minimum radius on the fastest through path around the *central island*.

circulating traffic—vehicles located on the *circulatory roadway*.

circulating volume—the total volume in a given period of time on the *circulatory roadway* immediately prior to an entrance.

circulatory roadway—the curved path used by vehicles to travel in a counterclockwise fashion around the *central island*.

circulatory roadway width—the width between the outer edge of the *circulatory roadway* and the central island, not including the width of any *apron*.

circulating speed—the speed vehicles travel at while on the *circulatory roadway*.

community enhancement roundabout—a *roundabout* used for aesthetic or community enhancement reasons, rather than as a solution to traffic problems. When used, often located in commercial and civic districts.

conflict point—a location where the paths of two vehicles, or a vehicle and a bicycle or pedestrian, merge, diverge, cross, or queue behind each other.

conflict, crossing—see *crossing conflict*.

conflict, diverge—see *diverge conflict*.

conflict, merge—see *merge conflict*.

conflict, queuing—see *queuing conflict*.

conflicting flows—the two paths that merge, diverge, cross, or queue behind each other at a *conflict point*.

control delay—delay experienced by vehicles at an intersection due to movements at slower speeds and stops on approaches as vehicles move up in the queue.

crash—a collision between a vehicle and another vehicle, a pedestrian, a bicycle, or a fixed object.

crash frequency—the average number of crashes at a location per period of time.

crash rate—the number of crashes at a location or on a roadway segment, divided by the number of vehicles entering the location or by the length of the segment.

CRF—see *capital recovery factor*.

crossing conflict—the intersection of two traffic streams, including pedestrians. Crossing conflicts are the most severe type of conflict.

curb extension—the construction of curbing such that the width of a street is reduced. Often used to provide space for parking or a bus stop or to reduce pedestrian crossing distances.

curb ramp—a short ramp cutting through a curb or built up to it (source: ADAAG).

curvature, approach—see *approach curvature*.

D factor—the proportion of the two-way traffic assigned to the peak direction.

D

deflection—the change in trajectory of a vehicle imposed by geometric features of the roadway.

degree of saturation—see *volume-to-capacity ratio*.

delay—additional travel time experienced by a driver, passenger, or pedestrian beyond what would reasonably be desired for a given trip.

delay, control—see *control delay*.

delay, geometric—see *geometric delay*.

demand flow—the number of vehicles or persons that would like to use a roadway facility during a specified period of time.

departure width—the width of the roadway used by departing traffic downstream of any changes in width associated with the *roundabout*. The departure width is typically no more than half the total roadway width.

design user—any user (motorized or nonmotorized) that can be reasonably be anticipated to use a facility.

design vehicle—the largest vehicle that can reasonably be anticipated to use a facility.

detectable warning surface—a standardized surface feature built in or applied to walking surfaces or other elements to warn visually impaired people of hazards on a circulation path (source: ADAAG).

diameter, inscribed circle—see *inscribed circle diameter*.

distance, set-back—see *set-back distance*.

diverge conflict—the separation of two traffic streams, typically the least severe of all conflicts.

double-lane roundabout—a *roundabout* that has at least one entry with two lanes, and a *circulatory roadway* that can accommodate more than one vehicle traveling side-by-side.

downstream—the direction toward which traffic is flowing (source: HCM 2000).

entering traffic—vehicles located on a *roundabout* entrance.

E

entering volume—the total volume in a given period of time on an entrance to a roundabout.

entry angle—term used in the United Kingdom regression models. It serves as a geometric proxy for the conflict angle between entering and circulating streams and is determined through a geometric construct. (source: UK Geometric Design of Roundabouts)

entry flare—the widening of an approach to multiple lanes to provide additional capacity at the *yield line* and storage.

entry flow—see *entering volume*.

entry path curvature—term used in the United Kingdom to describe a measure of the amount of entry *deflection* to the right imposed on vehicles at the entry to a roundabout. (source: UK Geometric Design of Roundabouts)

entry path radius—the minimum radius on the fastest through path prior to the yield line.

entry radius—the minimum radius of curvature of the outside curb at the entry.

entry speed—the speed a vehicle is traveling at as it crosses the *yield line*.

entry width—the width of the entry where it meets the *inscribed circle*, measured perpendicularly from the right edge of the entry to the intersection point of the left edge line and the inscribed circle.

entry, perpendicular—see *perpendicular entry*.

exit path radius—the minimum radius on the fastest through path into the exit.

exit radius—the minimum radius of curvature of the outside curb at the exit.

exit width—the width of the exit where it meets the *inscribed circle*, measured perpendicularly from the right edge of the exit to the intersection point of the left edge line and the *inscribed circle*.

exiting traffic—vehicles departing a *roundabout* by a particular exit.

extended splitter island—see *splitter island, extended*.

F **FHWA**—Federal Highway Administration.

flare—see *entry flare*.

flare, entry—see *entry flare*.

flow, circulating—see *circulating volume*.

flow, demand—see *demand flow*.

flow, entry—see *entry volume*.

flows, conflicting—see *conflicting flows*.

G **geometric delay**—the delay caused by the alignment of the lane or the path taken by the vehicle on a roadway or through an intersection.

geometric design—a term used in this document to describe the design of horizontal and vertical alignment and cross-sectional elements of a roadway.

give way—term used in the United Kingdom and Australia for *yield*.

“give way” rule—rule adopted in the United Kingdom in November 1966 which required that all vehicles entering a roundabout *give way*, or *yield*, to circulating vehicles.

H **HCM**—Highway Capacity Manual.

I **IES**—Illuminating Engineers Society.

incremental benefit-cost ratio—the difference in benefits between two alternatives, divided by the difference in costs between the two alternatives. See also *benefit-cost ratio*.

inscribed circle—the circle forming the outer edge of the *circulatory roadway*.

inscribed circle diameter—the basic parameter used to define the size of a *roundabout*, measured between the outer edges of the *circulatory roadway*. It is the diameter of the largest circle that can be inscribed within the outline of the *intersection*.

interchange—a grade-separated junction of two roadways, where movement from one roadway to the other is provided for.

intersection—an at-grade junction of two or more roadways.

intersection sight distance—the distance required for a driver without the right-of-way to perceive and react to the presence of conflicting vehicles.

island, central—see *central island*.

island, median—see *splitter island*.

island, separator—see *splitter island*.

island, splitter—see *splitter island*.

ITE—Institute of Transportation Engineers.

K factor—the proportion of the AADT assigned to the design hour.

K

left-turn path radius—the minimum radius on the fastest path of the conflicting left-turn movement.

L

level of service—a qualitative measure describing operational conditions within a traffic stream, generally described in terms of service measures such as speed and travel time, freedom to maneuver, traffic interruptions, comfort, and convenience.

line, yield—see *yield line*.

locking—stoppage of traffic on the *circulatory roadway* caused by queuing backing into the *roundabout* from one of the exits, resulting in traffic being unable to enter or circulate.

LOS—see *level of service*.

maximum service volume—the maximum hourly rate at which vehicles, bicycles, or persons can be reasonably expected to traverse a point or uniform section of a roadway during an hour under specific assumed conditions while maintaining a designated level of service. (source: HCM 2000)

M

measures of effectiveness—a quantitative parameter whose value is an indicator of the performance of a transportation facility or service from the perspective of the users of the facility or service.

median island—see *splitter island*.

merge conflict—the joining of two traffic streams.

mini-roundabout—small roundabouts used in low-speed urban environments. The *central island* is fully *mountable*, and the *splitter islands* are either painted or *mountable*.

model, crash prediction—see *crash prediction model*.

modern roundabout—a term used to distinguish newer *circular intersections* conforming to the characteristics of *roundabouts* from older-style *rotaries* and *traffic circles*.

m.o.e.—see *measures of effectiveness*.

mountable—used to describe geometric features that can be driven upon by vehicles without damage, but not intended to be in the normal path of traffic.

multilane roundabout—a *roundabout* that has at least one entry with two or more lanes, and a *circulatory roadway* that can accommodate more than one vehicle traveling side-by-side.

MUTCD—Manual on Uniform Traffic Control Devices.

neighborhood traffic circle—a *circular intersection* constructed at the intersection of two local streets for *traffic calming* and/or aesthetic purposes. They are generally not channelized, may be uncontrolled or stop-controlled, and may allow left turns to occur left (clockwise) of the *central island*.

N

nonconforming traffic circle—see *traffic circle*.

nontraversable—see *raised*.

O **O&M costs**—operations and maintenance costs.

P **peak hour factor**—the hourly volume during the maximum-volume hour of the day divided by the peak 15-minute flow rate within the peak hour; a measure of traffic demand fluctuation within the peak hour.

pedestrian refuge—an at-grade opening within a median island that allows pedestrians to safely wait for an acceptable gap in traffic.

perpendicular entry—an *entry angle* of 70 degrees or more.

PHF—see *peak hour factor*.

platoon—a group of vehicles or pedestrians traveling together as a group, either voluntarily or involuntarily because of signal control, geometrics, or other factors.

point, conflict—see *conflict point*.

priority—the assignment of *right-of-way* to a particular traffic stream or movement.

progression, signal—see *signal progression*.

Q **queue**—a line of vehicles, bicycles, or persons waiting to be served by the system in which the flow rate from the front of the queue determines the average speed within the queue. Slowly moving vehicles or persons joining the rear of the queue are usually considered a part of the queue. The internal queue dynamics may involve a series of starts and stops. (source: HCM 2000)

queuing conflict—a conflict that arises within a traffic stream between a lead vehicle and a following vehicle, when the lead vehicle must come to a stop.

R **radius, circulating path**—see *circulating path radius*.

radius, entry—see *entry radius*.

radius, entry path—see *entry path radius*.

radius, exit—see *exit radius*.

radius, exit path—see *exit path radius*.

radius, left-turn path—see *left-turn path radius*.

radius, right-turn path—see *right-turn path radius*.

raised—used to describe geometric features with a sharp elevation change that are not intended to be driven upon by vehicles at any time.

ramp, wheelchair—see *wheelchair ramp*.

refuge, pedestrian—see *pedestrian refuge*.

right-of-way—(1) an intersection user that has *priority* over other users. (2) Land owned by a public agency for transportation uses.

right-turn bypass lane—a lane provided adjacent to, but separated from, the *circulatory roadway*, that allows right-turning movements to bypass the *roundabout*. Also known as a *right-turn slip lane*.

right-turn path radius—the minimum radius on the fastest path of a right-turning vehicle.

right-turn slip lane—see *right-turn bypass lane*.

roadway, circulatory—see *circulatory roadway*.

rotary—a term used particularly in the Eastern U.S. to describe an older-style *circular intersection* that does not have one or more of the characteristics of a *roundabout*. They often have large diameters, often in excess of 100 m (300 ft), allowing high travel speeds on the *circulatory roadway*. Also known as a *traffic circle*.

roundabout—a *circular intersection* with yield control of all entering traffic, channelized approaches, counter-clockwise circulation, and appropriate geometric curvature to ensure that travel speeds on the *circulatory roadway* are typically less than 50 km/h (30 mph).

roundabout capacity—the maximum number of entering vehicles that can be reasonably expected to be served by a *roundabout* during a specified period of time.

roundabout, community enhancement—see *community enhancement roundabout*.

roundabout, modern—see *modern roundabout*.

roundabout, multilane—see *multilane roundabout*.

roundabout, rural double-lane—see *rural double-lane roundabout*.

roundabout, rural single-lane—see *rural single-lane roundabout*.

roundabout, single lane—see *single-lane roundabout*.

roundabout, urban compact—see *urban compact roundabout*.

roundabout, urban single-lane—see *urban single-lane roundabout*.

rural double-lane roundabout—a *roundabout* located in a rural area that has at least one entry with two lanes, and a *circulatory roadway* that can accommodate more than one vehicle traveling side-by-side. They incorporate *approach curvature* to slow *entering traffic* to a safe speed.

rural single-lane roundabout—a *roundabout* located in a rural area that has single lanes on all entries and one *circulatory lane*. This form typically has larger diameters and more tangential exits than urban forms.

separator island—see *median island*.

service volume—the hourly rate at which vehicles, bicycles, or persons can be reasonably expected to traverse a point or uniform section of a roadway during an hour under specific assumed conditions. See also *maximum service volume*. (Adapted from HCM 2000)

set-back distance—the distance between the edge of the *circulatory roadway* and the sidewalk.

sharpness of flare—a measure of the rate at which extra width is developed in the *entry flare*. (source: UK Geometric Design of Roundabouts)

sight distance, intersection—see *intersection sight distance*.

sight distance, stopping—see *stopping sight distance*.

sight triangle—an area required to be free of obstructions to enable visibility between conflicting movements.

signal progression—the use of coordinated traffic signals along a roadway in order to minimize stops and delay to through traffic on the major road.

single-lane roundabout—a *roundabout* that has single lanes on all entries and one *circulatory lane*.

speed table—an extended, flat-top road hump sometimes used at pedestrian crossings to slow traffic and to provide a better visual indication of the crosswalk location.

speed, approach—see *approach speed*.

speed, circulating—see *circulating speed*.

speed, entry—see *entry speed*.

S

splitter island—a raised or painted area on an approach used to separate entering from exiting traffic, deflect and slow entering traffic, and provide storage space for pedestrians crossing that intersection approach in two stages. Also known as a *median island* or a *separator island*.

splitter island, extended—a raised splitter island that begins some distance upstream of the pedestrian crossing to separate entering and exiting traffic. A design feature of rural roundabouts.

stopping sight distance—the distance along a roadway required for a driver to perceive and react to an object in the roadway and to brake to a complete stop before reaching that object.

T **traffic calming**—geometric treatments used to slow traffic speeds or to discourage the use of a roadway by nonlocal traffic.

traffic circle—a *circular intersection* that does not have one or more of the characteristics of a *roundabout*. Also known as a *rotary*.

traffic circle, neighborhood—see *neighborhood traffic circle*.

traffic circle, nonconforming—see *traffic circle*.

traffic design—a term used in this document to describe the design of traffic control devices, including signing, pavement markings, and construction traffic control.

traffic, circulating—see *circulating traffic*.

traffic, entering—see *entering traffic*.

truck apron—see *apron*.

two-stage crossing—a process in which pedestrians cross a roadway by crossing one direction of traffic at a time, waiting in a *pedestrian refuge* between the two traffic streams if necessary before completing the crossing.

two-way stop-control—stop signs are present on the approach(es) of the minor street. Drivers on the minor street or drivers turning left from the major street wait for a gap in the major street traffic in order to complete a maneuver.

TWSC—see *two-way stop control*.

U **U-turn**—a turning movement at an *intersection* in which a vehicle departs the intersection using the same roadway it used to enter the intersection.

upstream—the direction from which traffic is flowing (source: HCM 2000).

urban compact roundabout—a small *roundabout* with a raised *central island* and *splitter islands*, with perpendicular approaches that require vehicles to make a distinct right turn into the *circulatory roadway*.

urban double-lane roundabout—an urban *roundabout* with at least one entry with two lanes, and a *circulatory roadway* that can accommodate more than one vehicle traveling side-by-side. They have similar speed characteristics as *urban single-lane roundabouts*.

urban single-lane roundabout—a *roundabout* with single lane entries on all legs and one circulatory lane. Entries are less perpendicular than the *urban compact roundabout*, allowing somewhat higher speeds with higher capacities.

UVC—Uniform Vehicle Code.

V **vehicle, design**—see *design vehicle*.

volume, circulating—see *circulating volume*.

volume, entering—see *entering volume*.

volume, service—see *service volume*.

volume-to-capacity ratio—the ratio of flow rate to capacity for a transportation facility.

wheelchair ramp—see *curb ramp*.

width, approach—see *approach width*.

width, circulatory roadway—see *circulatory roadway width*.

width, departure—see *departure width*.

width, entry—see *entry width*.

width, exit—see *exit width*.

W

yield—an intersection control in which controlled traffic must stop only if higher *priority* traffic is present.

yield line—a pavement marking used to mark the point of entry from an approach into the *circulatory roadway* and generally marked along the *inscribed circle*. If necessary, *entering traffic* must yield to *circulating traffic* before crossing this line into the circulatory roadway.

Y

zebra crossing—a crossing marked by transverse white stripes where vehicles are required to yield to pedestrians.

Z

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Appendix A Operational Analysis Formulas

This appendix presents the assumptions used to develop the graphs and charts in the operational analysis presented in Chapter 4.

A.1 Single-Lane Roundabout

A.1.1 Equations

$$Q_e = k(F - f_c Q_c), \quad f_c Q_c \leq F \quad (\text{A-1})$$
$$= 0, \quad f_c Q_c > F$$

where: Q_e = entry capacity, pce/h
 Q_c = circulating flow, pce/h

$$k = 1 - 0.00347(\phi - 30) - 0.978\left(\frac{1}{r} - 0.05\right) \quad (\text{A-2})$$

$$F = 303x_2 \quad (\text{A-3})$$

$$f_c = 0.210t_D(1 + 0.2x_2) \quad (\text{A-4})$$

$$t_D = 1 + \frac{0.5}{1 + \exp\left(\frac{D - 60}{10}\right)} \quad (\text{A-5})$$

$$x_2 = v + \frac{e - v}{1 + 2S} \quad (\text{A-6})$$

$$S = \frac{1.6(e - v)}{l'} \quad (\text{A-7})$$

where: e = entry width, m
 v = approach half width, m
 l' = effective flare length, m
 S = sharpness of flare, m/m
 D = inscribed circle diameter, m
 ϕ = entry angle, degrees
 r = entry radius, m

For design purposes, when $e = v$ then I' is effectively zero. However, setting $I' = 0$ results in S being undefined. Therefore a non-zero value of I' has been selected. When $e = v$, any non-zero value of I' results in $S = 0$ and $x_2 = v$.

A.1.2 Parameter assumptions

$D = 40$ m
 $r_e = 20$ m
 $\phi = 30$ degrees
 $v = 4$ m
 $e = 4$ m
 $I' = 40$ m

$$S = \frac{1.6(e-v)}{I'} = \frac{1.6(4-4)}{40} = 0$$

$$t_D = 1 + \frac{0.5}{1 + \exp\left(\frac{D-60}{10}\right)} = 1.4404$$

$$x_2 = v + \frac{e-v}{1+2S} = 4 + \frac{4-4}{1+2(0)} = 4$$

$$F = 303x_2 = 303(4) = 1212$$

$$f_c = 0.210t_D(1+0.2x_2) = 0.5447$$

$$k = 1 - 0.00347(\phi - 30) - 0.978\left(\frac{1}{r} - 0.05\right) = 1$$

A.1.3 Final equation

$$Q_e = 1212 - 0.5447Q_c \tag{A-8}$$

A.2 Double-Lane Roundabout

A.2.1 Equations

See Section A.1.1.

A.2.2 Parameter assumptions

For design purposes, when $e = v$ then I' is effectively zero. However, setting $I' = 0$ results in S being undefined. Therefore a non-zero value of I' has been selected. When $e = v$, any non-zero value of I' results in $S = 0$ and $x_2 = v$.

$D = 55$ m
 $r_e = 20$ m
 $\phi = 30$ degrees
 $v = 8$ m
 $e = 8$ m
 $I' = 40$ m

$$S = \frac{1.6(e-v)}{I'} = \frac{1.6(8-8)}{40} = 0$$

$$t_D = 1 + \frac{0.5}{1 + \exp\left(\frac{D-60}{10}\right)} = 1.3112$$

$$x_2 = v + \frac{e-v}{1+2S} = 8 + \frac{8-8}{1+2(0)} = 8$$

$$F = 303x_2 = 303(8) = 2424$$

$$f_c = 0.210t_D(1+0.2x_2) = 0.7159$$

$$k = 1 - 0.00347(\phi - 30) - 0.978\left(\frac{1}{r} - 0.05\right) = 1$$

A.2.3 Final equation

$$Q_e = 2424 - 0.7159Q_c \quad (\text{A-9})$$

A.3 Urban Compact Roundabout

The capacity curve for the urban compact roundabout is based on the capacity curves developed for roundabouts in Germany with single-lane entries and a single-lane circulatory roadway. This equation, developed by Brilon, Wu, and Bondzio is as follows:

$$Q_e = 1218 - 0.74Q_c \quad (\text{A-10})$$

where: Q_e = entry capacity, pce/h
 Q_c = circulating flow, pce/h

A.4 Short Lanes

The effect of short lanes (flare) on capacity has been documented by Wu (3). Page 321 of Wu's paper states that for a right flared approach,

$$k_{f, right} = \frac{1}{n_{F, right+1} \sqrt{(x_L + x_T)^{n_{F, right+1}} + x_R^{n_{F, right+1}}}} \quad (A-11)$$

Dropping some subscripts,

$$k = \frac{1}{n+1 \sqrt{(x_{LT})^{n+1} + (x_R)^{n+1}}} \quad (A-12)$$

Noting that the capacities of each lane are the same and that the flows are the same (that is, the entries are constantly fed with vehicles), this gives:

$$k = \frac{1}{x^{n+1} \sqrt{2}} \quad (A-13)$$

with $x_{LT} = x_R$. Capacity q_{max} is then

$$q_{max} = k \quad q_i \quad (A-14)$$

where q_i is flow in lane i and $q_1 = q_2$

$$q_{max} = \frac{2q}{x^{n+1} \sqrt{2}} \quad (A-15)$$

q_{max2} is the capacity of a two-lane roundabout, the capacity of each entry lane is $q_{max2}/2$ and this is equal to the flow, q , divided by the degree of saturation, x .

$$q_{max} = \frac{q_{max2}}{n+1 \sqrt{2}} \quad (A-16)$$

The results of Equation A-16 can be compared with the results from the British equations. The TRL equations are listed above. The results are listed for four circulating flow conditions: 500 veh/h, 1000 veh/h, 1500 veh/h, and 2000 veh/h.

n	Q _c = 500 veh/h		Q _c = 1000 veh/h		Q _c = 1500 veh/h		Q _c = 2000 veh/h	
	TRL	Wu	TRL	Wu	TRL	Wu	TRL	Wu
0	940	940	668	668	395	395	123	123
1	1447	1461	1151	1208	855	955	559	702
2	1636	1640	1321	1356	1006	1072	691	787
3	1737	1737	1411	1436	1086	1135	761	834
4	1799	1799	1468	1487	1136	1175	805	864
5	1841	1841	1506	1522	1170	1203	835	884
6	1872	1871	1534	1547	1195	1223	857	899
7	1896	1895	1555	1566	1214	1238	873	910
8	1914	1913	1571	1581	1229	1250	886	919
9	1929	1928	1585	1594	1240	1260	896	926
10	1941	1940	1596	1604	1250	1268	905	932
11	1951	1950	1605	1612	1258	1274	912	936
12	1960	1959	1612	1619	1265	1280	918	941
13	1967	1966	1619	1626	1271	1285	923	944
14	1974	1973	1625	1631	1276	1289	928	947
15	1979	1978	1630	1636	1281	1293	931	950
16	1984	1983	1635	1640	1285	1296	935	952
17	1989	1988	1639	1644	1288	1299	938	955
18	1993	1992	1642	1647	1292	1302	941	957
19	1996	1996	1645	1650	1294	1304	943	958
20	2000	1999	1648	1653	1297	1306	946	960
	2066	2066	1708	1708	1350	1350	992	992

Exhibit A-1. Tabular comparison of TRL and Wu short-lane methodologies.

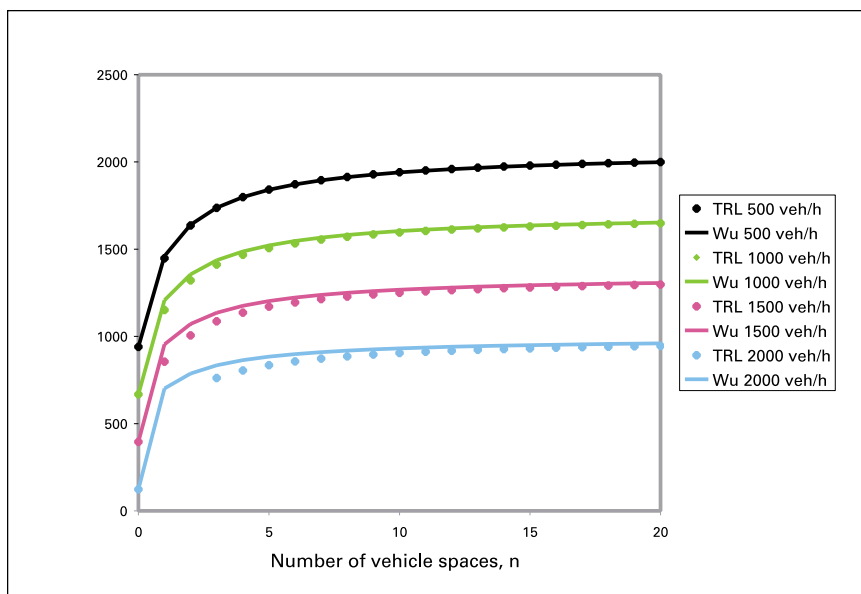


Exhibit A-2. Graphical comparison of TRL and Wu short-lane methodologies.

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3. Wu, N. "Capacity of shared/short lanes at unsignalized intersections." In *Proceedings of the Third International Symposium on Intersections without Traffic Signals* (ed: M. Kyte), Portland, Oregon, U.S.A. University of Idaho, 1997.

Appendix B Example Roundabout Designs

The purpose of this Appendix is to provide examples for each of the six roundabout categories. Exhibit B-1 lists typical inscribed circle diameter ranges for each roundabout category. Note that the flared-entry roundabout uses the same range of inscribed circle diameters as the double-lane roundabouts. Note that the dimensions of roundabouts may vary considerably within each category, depending on site-specific characteristics, including number of legs, approach angles, design vehicle requirements, and so on. Refer to Chapter 6 for more discussion of specific dimensions.

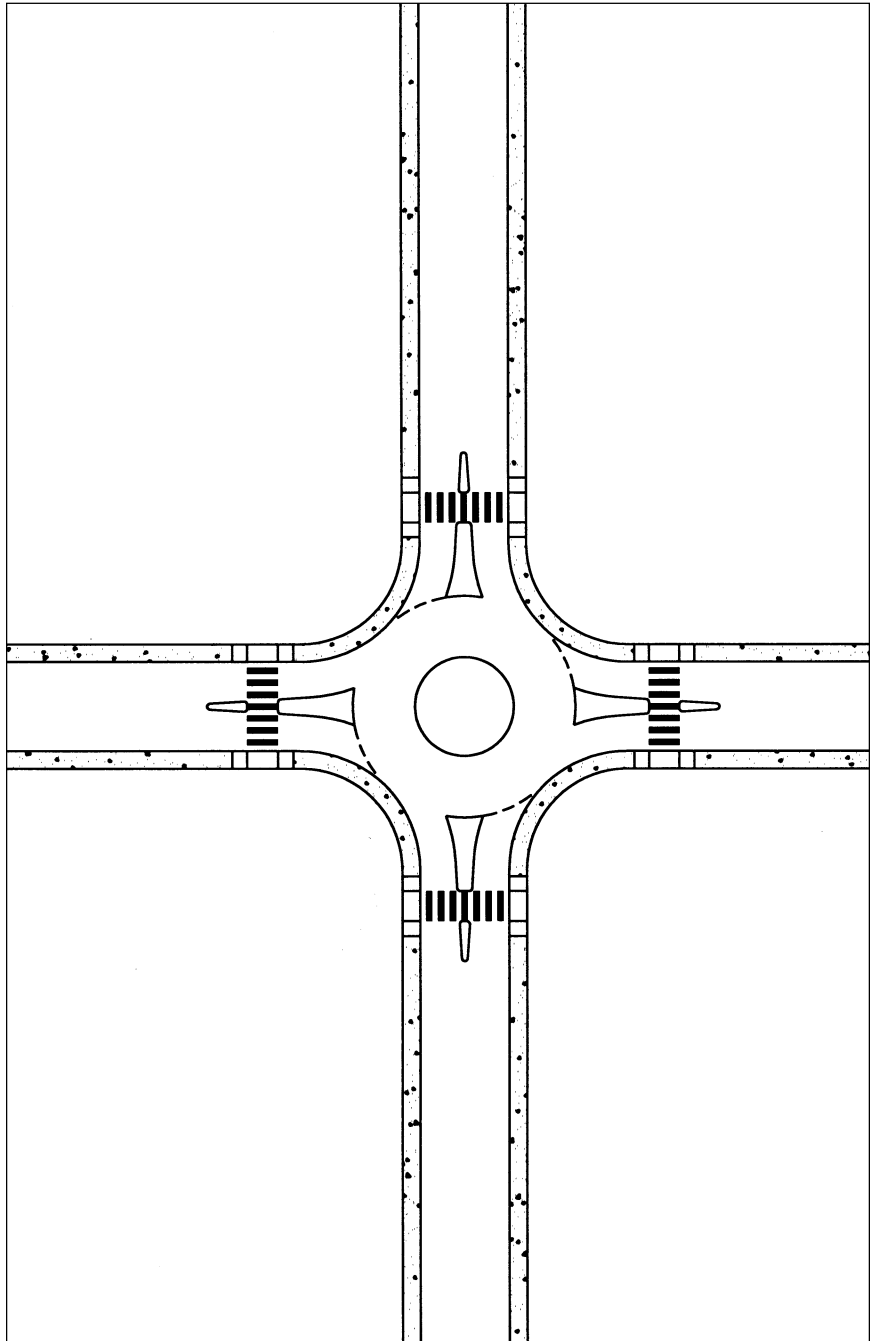
Exhibit B-1. Typical inscribed circle diameter ranges by roundabout category.

Site Category	Inscribed Circle Diameter Range
Mini-roundabout	13–25 m (45–80 ft)
Urban compact	25–30 m (80–100 ft)
Urban single lane	30–40 m (100–130 ft)
Urban double lane	45–55 m (150–180 ft)
Rural single lane	35–40 m (115–130 ft)
Rural double lane	55–60 m (180–200 ft)

The following pages show examples for each of the roundabout categories:

- Exhibit B-2: Typical mini-roundabout.
- Exhibit B-3: Typical urban compact roundabout.
- Exhibit B-4: Typical urban single-lane roundabout.
- Exhibit B-5: Typical urban double-lane roundabout.
- Exhibit B-6: Typical flared-entry roundabout.
- Exhibit B-7: Typical rural single-lane roundabout.
- Exhibit B-8: Typical rural double-lane roundabout.

Exhibit B-2. Example of a typical mini-roundabout.



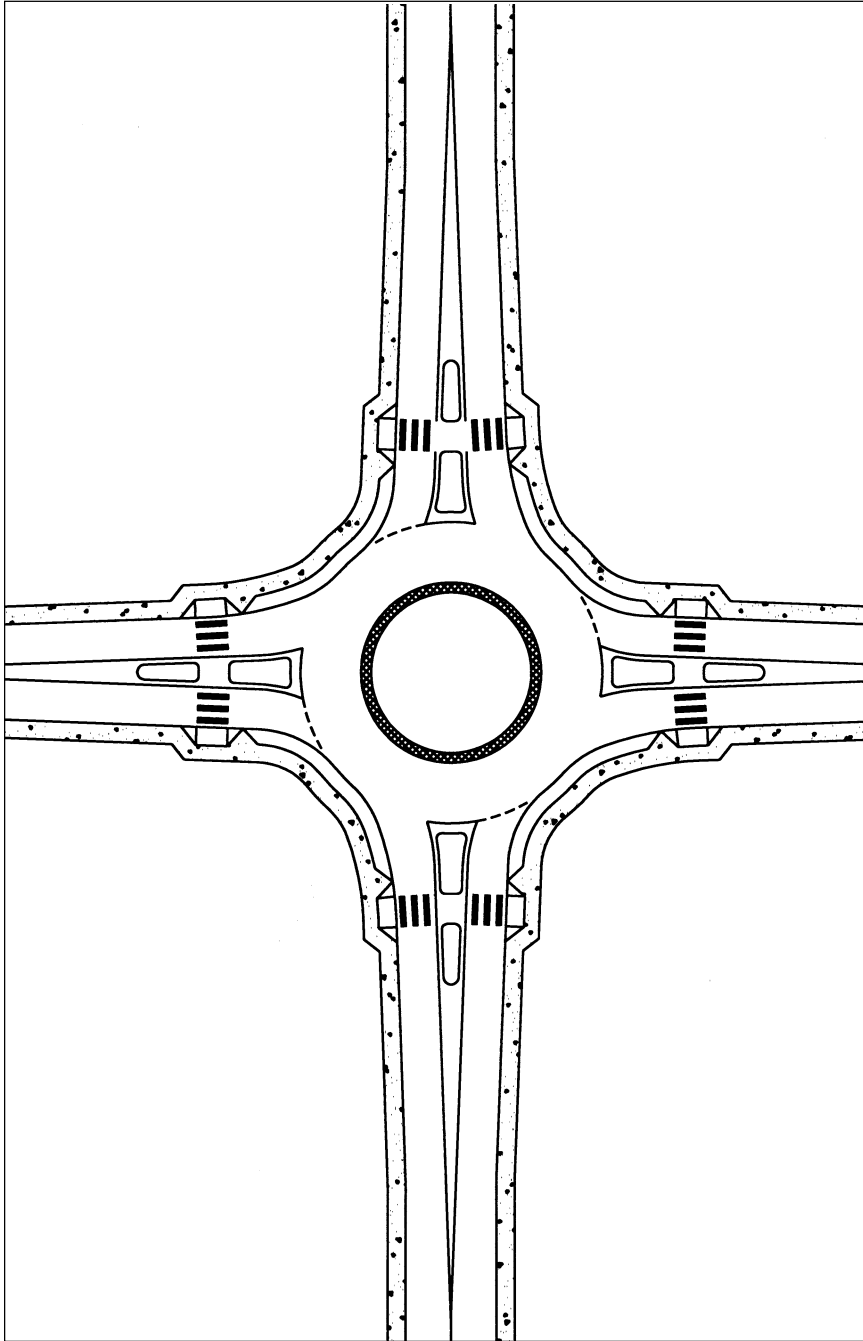
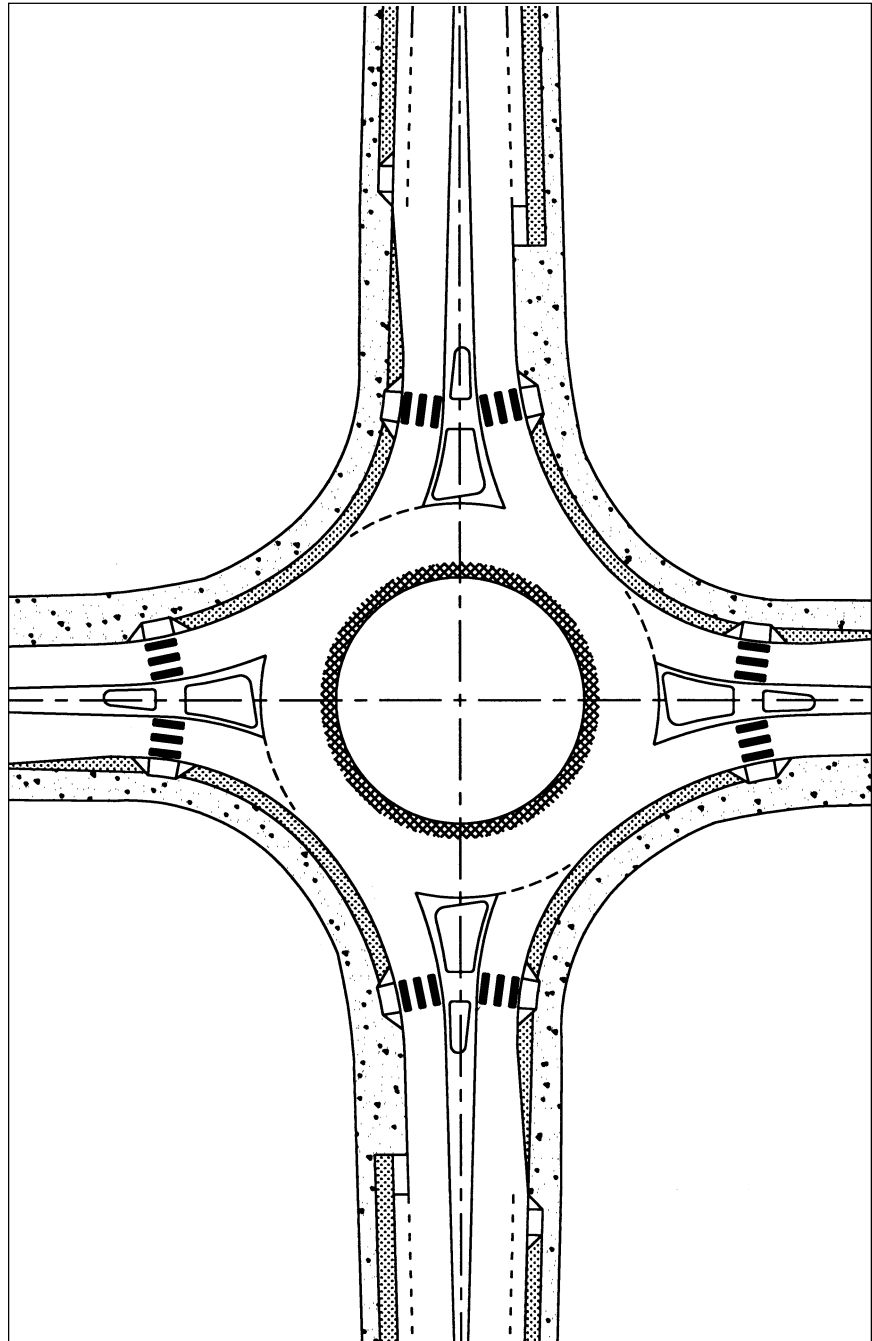


Exhibit B-3. Example of a typical urban compact roundabout.

Exhibit B-4. Example of a typical single-lane roundabout.



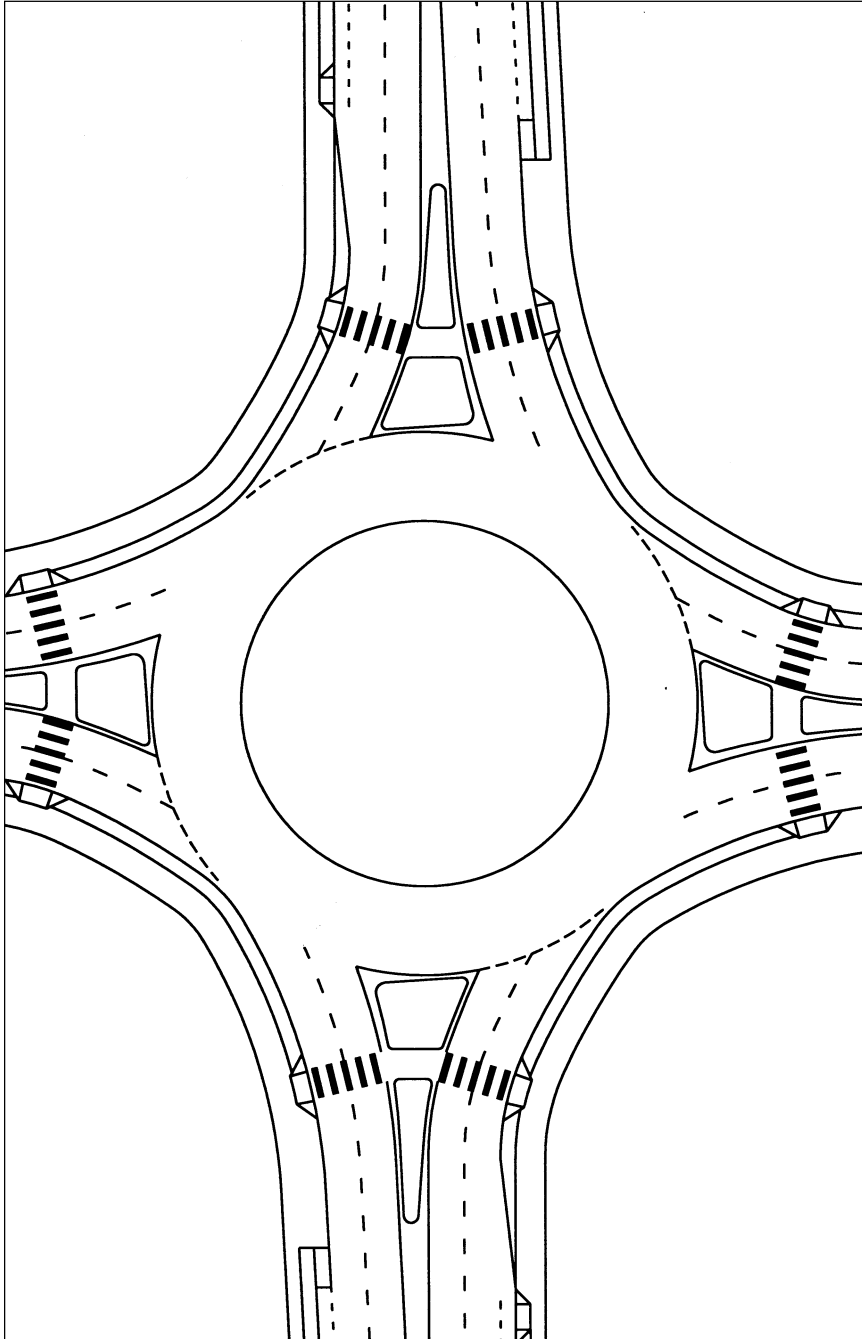
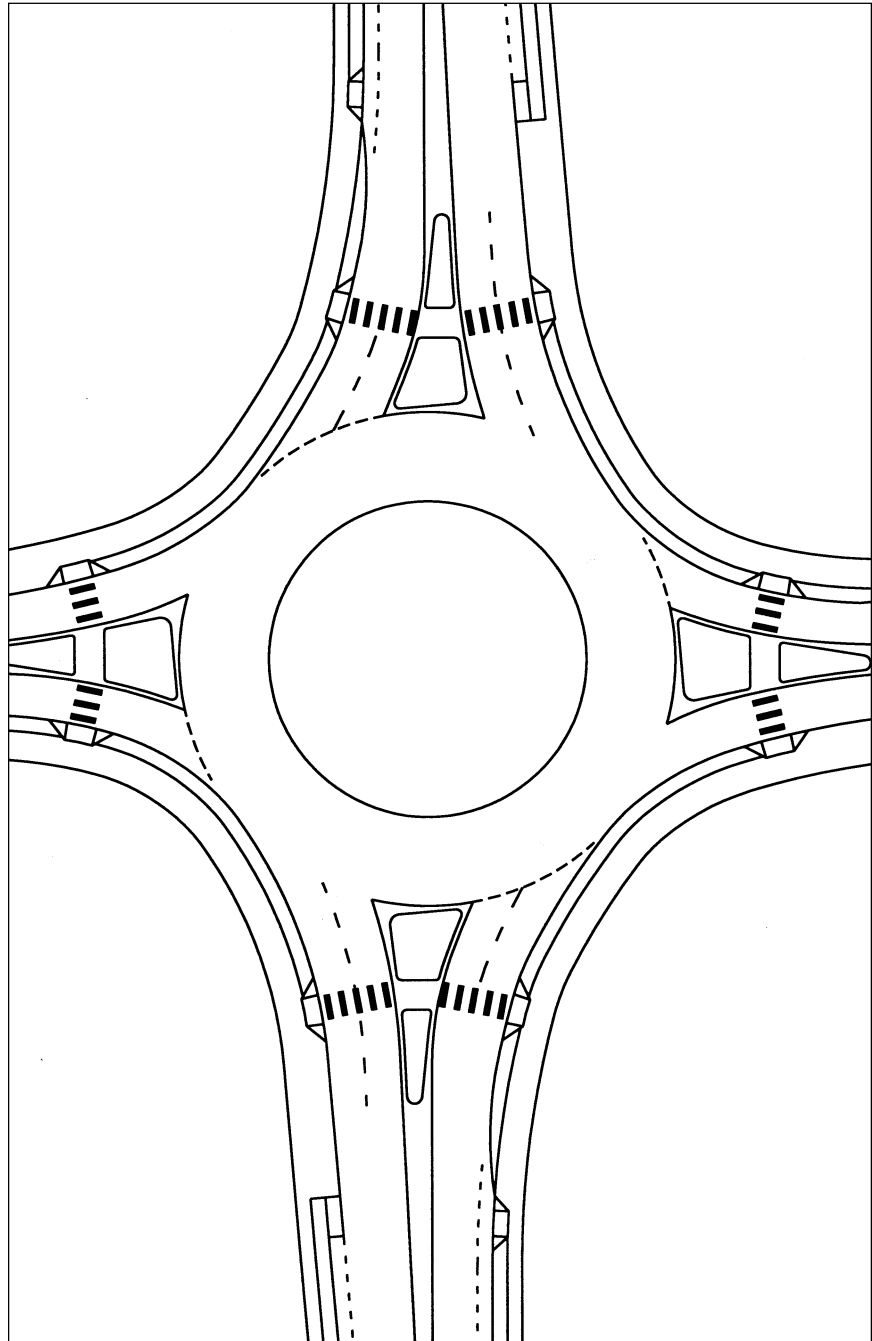


Exhibit B-5. Example of a typical urban double-lane roundabout.

Exhibit B-6. Example of a typical flared-entry roundabout.



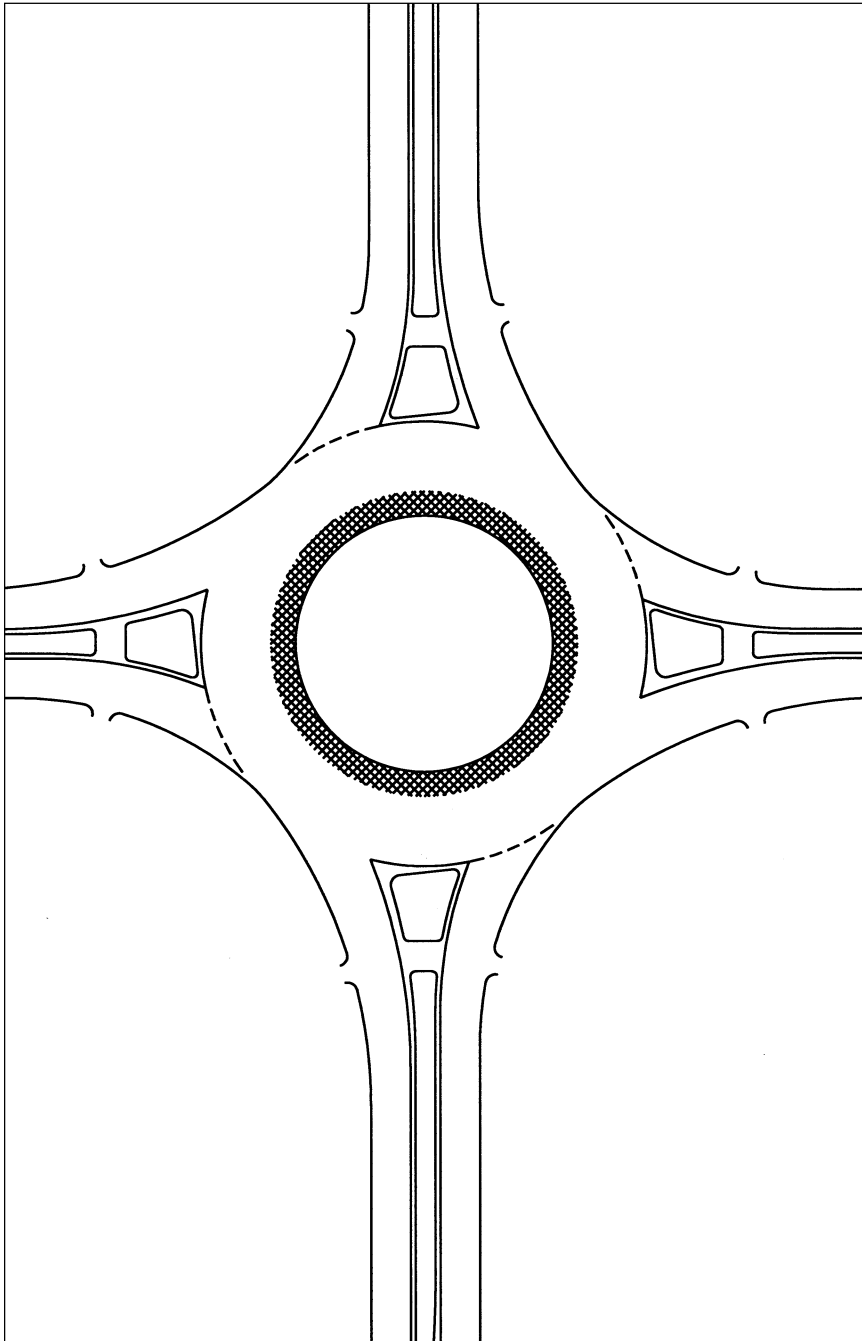
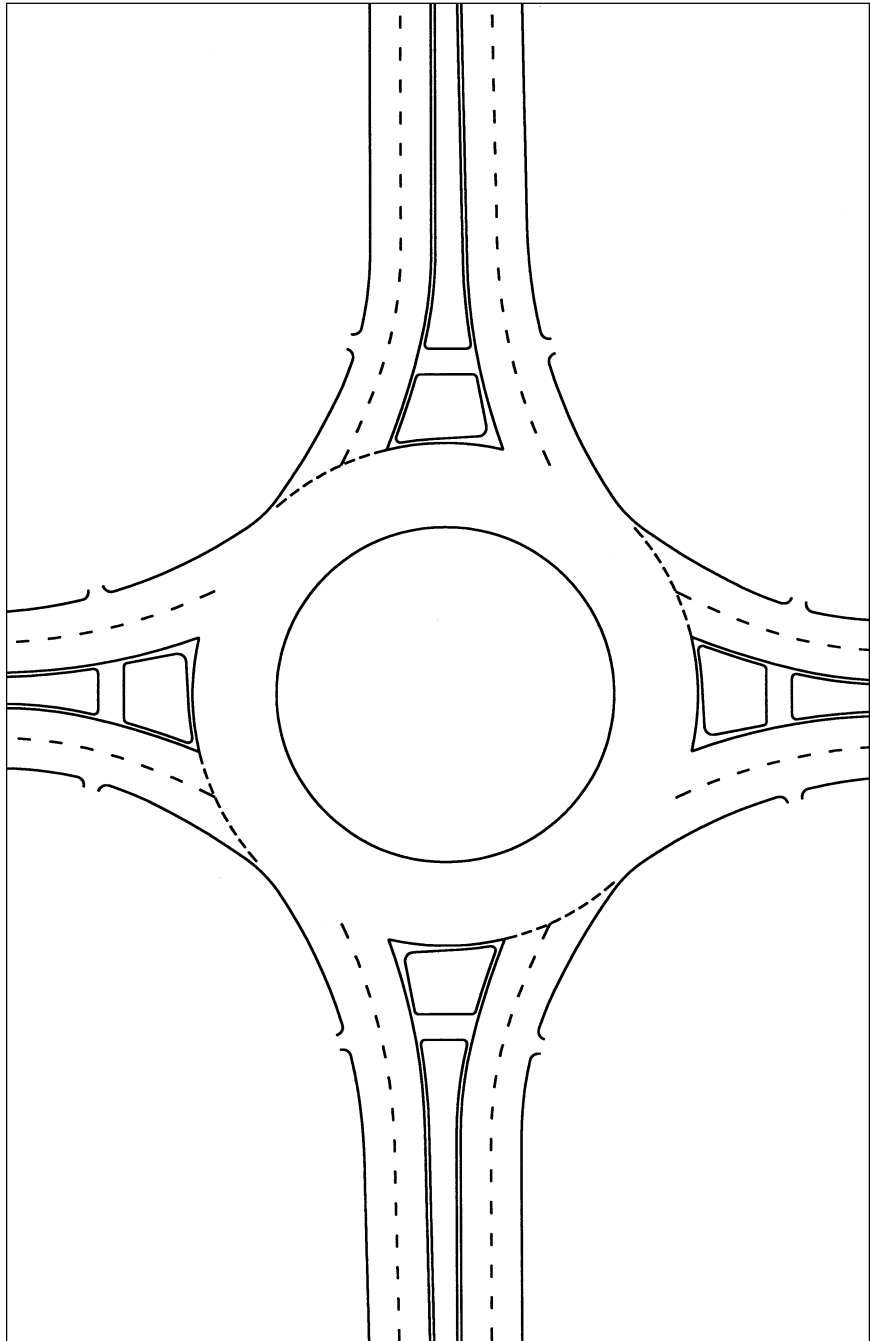


Exhibit B-7. Example of a typical rural single-lane roundabout.

Exhibit B-8. Example of a typical rural double-lane roundabout.



Appendix C MUTCD Recommendation

The purpose of this Appendix is to provide the rationale behind recommended deviations from the current (1988 edition) or proposed (2000 edition) *Manual on Uniform Traffic Control Devices* (MUTCD). The following devices are discussed:

- YIELD Sign
- Roundabout Ahead Sign

C.1 Yield Sign

The proposed use of the YIELD sign in the Guide is generally consistent with the MUTCD. However, the MUTCD contains language that generally discourages the use of YIELD signs for controlling the major flow at an intersection and the use of YIELD signs on more than one approach (MUTCD, §2B-8). This language predates the consideration of roundabouts and should be modified in the next edition of the MUTCD.

C.2 Roundabout Ahead Sign

As an alternative to the Circular Intersection sign, a Roundabout Ahead sign has been proposed. This sign, along with a supplemental advisory speed plate (W13-1), is shown in Exhibit C-1.



Exhibit C-1. Roundabout Ahead sign with advisory speed plate (W13-1).

This sign should be used on all approaches to a roundabout. The purpose of a Roundabout Ahead sign is to convey to a driver that the driver is approaching an intersection with the form of a roundabout. The intent of this sign is to be similar in function to the other intersection warning signs (e.g., CROSS ROAD (W2-1) signs), for example, which convey that the driver is approaching intersections of those forms. Unlike those signs, however, the Roundabout Ahead sign is recommended for all roundabouts, not just visually obscured locations.

C.2.1 Need

The 1988 edition of the MUTCD provides no sign related to roundabouts. The closest applicable sign is the YIELD AHEAD sign, either in word message or symbolic form (W3-2 or W3-2a, respectively). While this sign is necessary for indicating an upcoming traffic control device, it does not provide any information to the driver that the upcoming yield sign is for a roundabout. Driver behavior, lane assignments,

and driver expectation are much different for roundabouts than for traditional yield-controlled locations (typically low-volume streets or right-turn bypass lanes). Identification that a roundabout is upcoming is particularly important for multilane approaches so that drivers can anticipate and move into the proper lane in advance of the roundabout. Therefore, some indication that a driver is approaching a roundabout is essential, especially given the relative rarity of roundabouts in the United States.

The National Committee on Uniform Traffic Control Devices (NCUTCD) has adopted the Circular Intersection sign shown in Exhibit C-2, and this sign is being considered for adoption by FHWA.

Exhibit C-2. Circular Intersection sign.



C.2.2 Existing Practice

Due to the lack of a standard Roundabout Ahead sign, jurisdictions in the U.S. have experimented with a variety of warning signs, sometimes with multiple variations within the same jurisdiction. Examples of these are shown in Exhibit C-3. As can be seen from the figure, the lack of standardization from jurisdiction to jurisdiction is evident.

Exhibit C-3. Sample of existing Roundabout Ahead signs in United States.

- Bradenton Beach, FL (a)
- Mary Esther, FL (b)
- Mary Esther, FL (c)
- Lisbon, MD (d)
- Leeds, MD (e)
- Lothian, MD (f)
- Naples, FL (g)
- West Boca Raton, FL (h)





Exhibit C-3 (continued).

- (i) Santa Barbara, CA
- (j) Tallahassee, FL
- (k) Taneytown, MD
- (l) Tavares, FL
- (m) Vail, CO
- (n) West Vail, CO

International practice varies from country to country but is generally more consistent than current U.S. practice. Sign shapes and coloration vary depending on the standards of that country, but the one consistent feature is a simple ring of arrows, oriented to the direction of traffic flow. Examples from the United Kingdom and Australia are given in Exhibit C-4.



United Kingdom

Australia

Exhibit C-4. Sample of Roundabout Ahead signs used internationally.

C.2.3 Recommendation

Based on a review of existing signs in the U.S. and current international practice, a recommended Roundabout Ahead sign was developed, as presented previously in Exhibit C-1. This sign is similar in concept to those shown in (b), (c), and (j) of Exhibit C-3 and is shown fully dimensioned in Exhibit C-5. This sign has been developed based on the following criteria:

- The recommended sign is symbolic, consistent with current MUTCD practice.
- The recommended sign uses the internationally recognized circular ring of arrows to represent a roundabout and is almost an exact mirror image of the sign used in Australia (Exhibit C-4).
- The recommended sign gives advanced notice of the proper direction of circulation. The NCUTCD-adopted sign in Exhibit C-2 does not convey this information and could give the driver the incorrect impression that the circulatory roadway is bidirectional.

- The recommended sign can be used for roundabouts with any number of legs, including intersections with one-way approaches. Many of the signs in Exhibit C-3 and the NCUTCD-recommended sign in Exhibit C-2 are unique to four-leg roundabouts with legs at right angles and would be inappropriate for roundabouts with three or five legs, for example.
- The recommended sign can be supplemented by an advisory speed plate. An advisory speed plate would not be appropriate for a YIELD AHEAD sign because of the need for the driver to proceed only when clear.
- The recommended sign is simple with no extraneous or distracting elements to confuse a driver. Some of the signs in Exhibit C-3 are perhaps too complex for higher speed environments.
- Mini-roundabouts cannot be easily signed to show the proper direction of circulation. The recommended sign provides guidance to the driver as to the proper direction of circulation.

Exhibit C-5. Dimensions of Roundabout Ahead sign.

