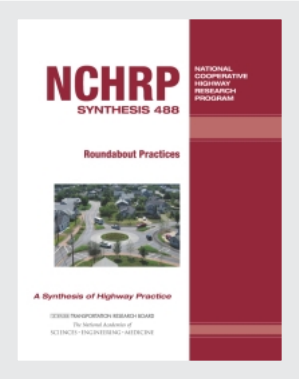

Roundabout Practices

DETAILS

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP SYNTHESIS 488

Roundabout Practices

A Synthesis of Highway Practice

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and
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Kittelson & Associates, Inc.

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research is the most effective way to solve many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation results in increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

Recognizing this need, the leadership of the American Association of State Highway and Transportation Officials (AASHTO) in 1962 initiated an objective national highway research program using modern scientific techniques—the National Cooperative Highway Research Program (NCHRP). NCHRP is supported on a continuing basis by funds from participating member states of AASHTO and receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board (TRB) of the National Academies of Sciences, Engineering, and Medicine was requested by AASHTO to administer the research program because of TRB's recognized objectivity and understanding of modern research practices. TRB is uniquely suited for this purpose for many reasons: TRB maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; TRB possesses avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; TRB's relationship to the Academies is an insurance of objectivity; and TRB maintains a full-time staff of specialists in highway transportation matters to bring the findings of research directly to those in a position to use them.

The program is developed on the basis of research needs identified by chief administrators and other staff of the highway and transportation departments and by committees of AASHTO. Topics of the highest merit are selected by the AASHTO Standing Committee on Research (SCOR), and each year SCOR's recommendations are proposed to the AASHTO Board of Directors and the Academies. Research projects to address these topics are defined by NCHRP, and qualified research agencies are selected from submitted proposals. Administration and surveillance of research contracts are the responsibilities of the Academies and TRB.

The needs for highway research are many, and NCHRP can make significant contributions to solving highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement, rather than to substitute for or duplicate, other highway research programs.

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Cover figure: Roundabout. *Courtesy*: Town of Nantucket, Massachusetts via Greenman–Pedersen, Inc.

FOREWORD

Highway administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to highway administrators and engineers. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire highway community, the American Association of State Highway and Transportation Officials—through the mechanism of the National Cooperative Highway Research Program—authorized the Transportation Research Board to undertake a continuing study. This study, NCHRP Project 20-5, "Synthesis of Information Related to Highway Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an NCHRP report series, *Synthesis of Highway Practice.*

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

By Jo Allen Gause
Senior Program Officer
Transportation Research Board

In mid-1997, *NCHRP Synthesis of Highway Practice 264: Modern Roundabout Practice in the United States* identified 50 roundabouts known to have been constructed since the beginning of the decade. As of 2013, there were an estimated 3,200 roundabouts in use throughout the country. This synthesis documents and summarizes roundabout policies, guidance, and practices in place within state departments of transportation (DOTs) as of 2015. The primary focus of the synthesis is on roundabout selection and design with a secondary focus on performance analysis.

Information used in this study was gathered through a literature review and a survey of state DOTs. Personnel from seven states were interviewed to create case examples and more specific information.

Alek Pochowski, Andy Paul, and Lee A. Rodegerdts, Kittelson & Associates, Inc., collected and synthesized the information and wrote the report. The members of the topic panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable with the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

Note: Photographs, figures, and tables in this report may have been converted from color to grayscale for printing. The electronic version of the report (posted on the web at www.trb.org) retains the color versions.

ROUNDABOUT PRACTICES

SUMMARY

Over the past 25 years, traffic roundabouts have gone from nonexistent in the United States to being found in every state. In that time, state agencies have continued to update their roundabout policies, guidance, and practices, and this synthesis documents and summarizes these practices within state departments of transportation (DOTs) as of 2015. The intent of the synthesis is twofold: to be a useful reference to agencies that are creating or updating roundabout and/or intersection control policies; and to provide updated information about current roundabout practices.

The synthesis was completed in three stages. The first stage comprised a comprehensive literature review of relevant published national materials and ongoing research projects, focusing on the design, operational analysis, and safety analysis practices of roundabouts. During the second stage, a questionnaire concerning the selection, performance analysis, and design of roundabouts was sent to the 52 AASHTO member departments (50 states, plus the District of Columbia and Puerto Rico), and responses were received from 40 states, an 80% response rate. In the final stage, state DOT personnel from seven states—California, Connecticut, Georgia, Kansas, Maryland, Minnesota, and Washington—were interviewed to provide case examples and to elaborate on survey responses.

From 1990, when the first roundabout in the United States was constructed, to 2013, approximately 3,200 roundabouts are estimated to have been built. In general, roundabouts have been constructed at an increasing rate each year, and by 2010, all 50 states and the District of Columbia had a roundabout. Single-lane roundabouts have consistently been the most common type constructed, although the ratio of multilane roundabouts to single-lane roundabouts has increased slightly over the last decade.

Agency policies, guidance, and practices regarding the selection and design of roundabouts vary across the United States. Currently, 11 states formally require the analysis of roundabout alternatives, and 19 additional states encourage the analysis of roundabout alternatives. Although some states make reference to *NCHRP Report 672* for design guidance, other states go further than simply referencing the federal guidance and provide supplemental material or have developed standalone guidance.

Of the 40 states that responded to the questionnaire, 38 have a roundabout in operation. Of the two states that reported their agency has not built a roundabout on the state highway system, one reported that a roundabout has been planned or designed but has not yet been built, and the other is considering the construction of roundabouts. By comparison, the 1998 *Synthesis of Highway Practice 264: Modern Roundabout Practice in the United States* identified only nine state agencies with a roundabout in operation, under construction, or in design as of 1997; only about one-third of the states without a roundabout on their state highway system was considering the construction of roundabouts.

The questionnaire addressed practices within state DOTs, including the primary reasons for the selection of roundabouts, cost, public education material, and roundabout performance analysis. In addition, questions were asked regarding the design of roundabouts, including the

use of design guidance, design life, design-vehicle guidance, and illumination of roundabouts. A brief summary of responses, detailed in chapter three, is provided here:

- The primary reason cited for the selection of roundabouts is improved safety performance compared with other intersection options, followed by shorter vehicular delays and higher capacity.
- Respondents provided planning-level cost estimates (screening or feasibility level estimates) for mini-, single-lane, and multilane roundabouts, which range from $249,000 to $2.05 million.
- The majority of reporting states have developed some public education materials to support roundabout projects, such as websites, videos, and flyers and/or pamphlets.
- To analyze roundabout performance, about three-quarters of the reporting states use some form of the *Highway Capacity Manual* 2010 model and SIDRA's Standard Model; about one-quarter use some form of the United Kingdom equations. (Because states were allowed to select more than one operational performance model, there is some overlap.)
- Most of the reporting states analyze safety performance at roundabouts, using crash modification factors, crash reduction factors, and/or the *Highway Safety Manual* predictive methodology.
- *NCHRP Report 672: Roundabouts: An Informational Guide*, 2nd edition, is used by most of the reporting state agencies for at least some design guidance.
- Most states use a design life of 20 years when developing the ultimate roundabout design. However, the majority uses a phased implementation approach, and a few indicated they would be open to an operational projection of 10 years.
- Half of the reporting states indicated that their agency had developed design-vehicle guidance that typically conforms to large tractor-trailer trucks.
- All of the reporting states follow developed illumination guidance, with only one state indicating it does not require the illumination of roundabouts.

To expand on the information collected in the questionnaire, and to get more in-depth information on topics such as the selection of roundabouts, experience with using a phased roundabout implementation approach, modifications to existing roundabouts, and the use of accelerated low-cost roundabouts, several states were asked to participate in interviews. A summary of information obtained from the state interviews, also provided in more detail in chapter four and Appendix D, is provided here:

- Although interview participants cited safety as the number-one driver behind the selection of roundabouts, several of the interview participants cited challenges with evaluating roundabouts on an equal footing with other intersection control options.
- All of the interviewed early adopter states (defined as having built a roundabout before the year 2000) had experienced the need to modify existing roundabouts resulting from identified safety or operational problems.
- Most interview participants indicated they use a default design vehicle of a large tractor-trailer truck for roundabout movements along state routes.
- Several interview participants reported experience with accelerated, low-cost roundabouts, which involves roundabouts implemented at a substantially reduced cost or time period compared with a typical roundabout installation. The early adopter states planned for, constructed, and built roundabouts prior to any type of federal design guidance, and while the interview participants indicated they experienced some challenges and the need to modify their early designs, they indicated that their journey helped pave the way for roundabouts to be installed throughout the United States. This synthesis documents some of the past and present experiences of these early adopter states.

In addition, the current state of the practice at other state DOTs documented in this synthesis emphasizes the lessons learned from these early adopter states. However, this synthesis also suggests topics for further research, including the development of a third edition of *Roundabouts: An Informational Guide*, strategies for increasing the cost-effectiveness of roundabout installations, and the effectiveness of intersection control policies.

CHAPTER ONE

INTRODUCTION

In mid-1997, the *Synthesis of Highway Practice 264: Modern Roundabout Practice in the United States* (*1*) identified 50 roundabouts known to have been constructed since the beginning of that decade. As of 2013, there were an estimated 3,200 roundabouts in use throughout the country (*2*). To deal with the continual expansion of roundabouts in the United States, states and municipal roadway agencies now use a range of sources and engineering judgment to establish policies and design guidelines for roundabouts.

OBJECTIVES OF STUDY

The purpose of this synthesis was to document and summarize roundabout policies, guidance, and practices in place as of 2015 within state departments of transportation (DOTs). Its primary focus was on roundabout selection and design with a secondary focus on performance analysis. The synthesis was intended to be a useful reference to agencies that are creating or updating roundabout and intersection control policies. The specific objectives included the documentation of roundabout growth in the United States, statewide roundabout policies, and public outreach efforts. A survey sent to all state DOTs provided useful information on reasons that agencies have selected roundabouts, planning-level cost estimates of roundabouts, state efforts to quantify roundabout operational performance, the extent to which agencies used *NCHRP Report 672* for roundabout design guidelines, whether agencies had existing standards or guidance for lighting at roundabouts, and how states accommodated design vehicles (specifically, trucks). Interviews with selected state DOTs addressed questions related to modifications to existing roundabouts, whether agencies were using a phased roundabout design approach over the project life, and the use of accelerated low-cost roundabouts.

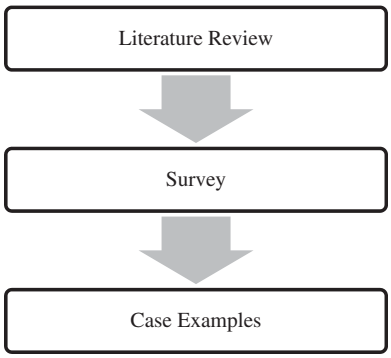


FIGURE 1 Study approach stages.

STUDY APPROACH

The synthesis was completed in three stages, shown in Figure 1. The first stage included a comprehensive literature review of relevant published national materials and ongoing research projects focusing on the design, operational analysis, and safety analysis practices of roundabouts. During the second stage, a questionnaire concerning the selection, performance analysis, and design of roundabouts was sent to all 50 states, as well as Washington, D.C. and Puerto Rico. In the final stage, state DOT personnel from seven states were interviewed to create case examples and more specific information.

SYNTHESIS ORGANIZATION

This synthesis document is divided in sections based on how the material was sourced. The literature review is summarized in chapter two; the survey results are presented in chapter three; and the case examples are summarized in chapter four. The report concludes with the identification of key findings and suggestions for future research. Consistent with all synthesis projects, the report does not contain policy or design recommendations.

CHAPTER TWO

LITERATURE REVIEW

ROUNDABOUTS IN THE UNITED STATES

Although the first traffic circle in the United States was built at New York City's Columbus Circle in 1905, with one-way circulation, the roundabout was officially invented in 1966, when the off-side priority rule (meaning entering drivers yield to circulating drivers) was adopted in Great Britain. According to *NCHRP Synthesis 264*, roundabouts were constructed in Australia and France in the 1970s, and were officially moved into practice in France in 1984. In the meantime, however, in this country, traffic circles fell out of favor in the 1950s, as a result of operational and safety problems associated with rotary intersections, including high speeds, weaving issues, and the tendency to lock up at higher volumes. The first two modern roundabouts in the United States were constructed in 1990 in Summerlin, Nevada (*1*).

This chapter discusses the growth of roundabouts in the United States since 1990, along with current statewide roundabout policies; statewide statutes, codes, and laws pertaining to roundabouts; public outreach efforts; current research on roundabout performance; and a snapshot of the most effective practices related to the design of roundabouts.

Growth of Roundabouts

In the first 10 years following the introduction of roundabouts in Nevada, only 30 states were known to have built at least one roundabout, as shown in Figure 2; and only four states were known to have had more than 25 roundabouts. After the opening of two roundabouts in Fairmont, West Virginia, in 2010 (*3*), every state and the District of Columbia had at least one roundabout, as shown in Figure 3. By 2013, approximately 3,200 roundabouts are estimated to have been constructed (*2*).

In general, roundabouts have been constructed at an increasing rate per year since 1990, as shown in Figure 4. The data in this figure comes from an online roundabout database from Kittelson & Associates (*3*) and has been adjusted to reflect the likely number of roundabouts constructed in the United States by providing assumptions for the number of unknown roundabouts. These assumptions are based on the number of roundabouts missing from previous years' records compared with the number of roundabouts that are now known to exist, and does not include "nonconforming" traffic circles (*2*). As shown in Figure 5, the number of roundabouts in the United States has increased in tandem with the development and publication of design guides and research (*4*).

Types of Roundabouts

Although the first two roundabouts constructed in the United States were multilane, the Kittelson & Associates website indicates that the majority of roundabouts constructed since have been single-lane roundabouts—as of 2013, 71%. However, this is a decrease from 2005, when approximately 78% of known roundabouts in the United States were single-lane. The first known mini-roundabouts in the United States, 17 of them, were constructed in 2000; However, FHWA has only identified 12 mini-roundabouts as of December 2013 (*5*). Figure 6 displays the cumulative percent of roundabouts constructed in the United States by type. (Unlike Figure 4, Figure 6 only includes roundabouts where both the roundabout type and year constructed are known.)

Although all roundabouts are generally circular—Figures 7, 8, and 9 show mini-, single-lane, and multilane roundabouts, respectively—roundabouts exist that are not pure circles, with oblong, elliptical, raindrop, and dumbbell shapes (*6–8*). Examples include the oblong-shaped Rochester roundabout shown in Figure 10, located in Rochester Borough, Pennsylvania (*10*). The I-135/1st Street roundabout in Newton, Kansas, shown in Figure 11, is an example of an elliptical roundabout (*11*). The I-70/Avon Road roundabouts shown in Figure 12 displays two examples of raindrop-shaped roundabout designs located at the interchange ramp terminals (*12*). A series of dumbbell-shaped roundabouts are located on Keystone Parkway in Carmel, Indiana; the Keystone Parkway/E. 116th Street intersection dumbbell roundabout, as shown in Figure 13 (*13*).

ROUNDABOUT POLICIES

A 2010 study of existing statewide policies was reviewed to assess the status of roundabout policies in the United States (*14*). The 2010 review was conducted by examining information available online, including state agency roundabout websites, or other state DOT web pages. The review split the roundabout policy types into six categories. For the purposes of this synthesis, the two strongest roundabout categories ("Strong" and "Justify") were combined into a new category termed "Preferred." The five categories are shown in Table 1.

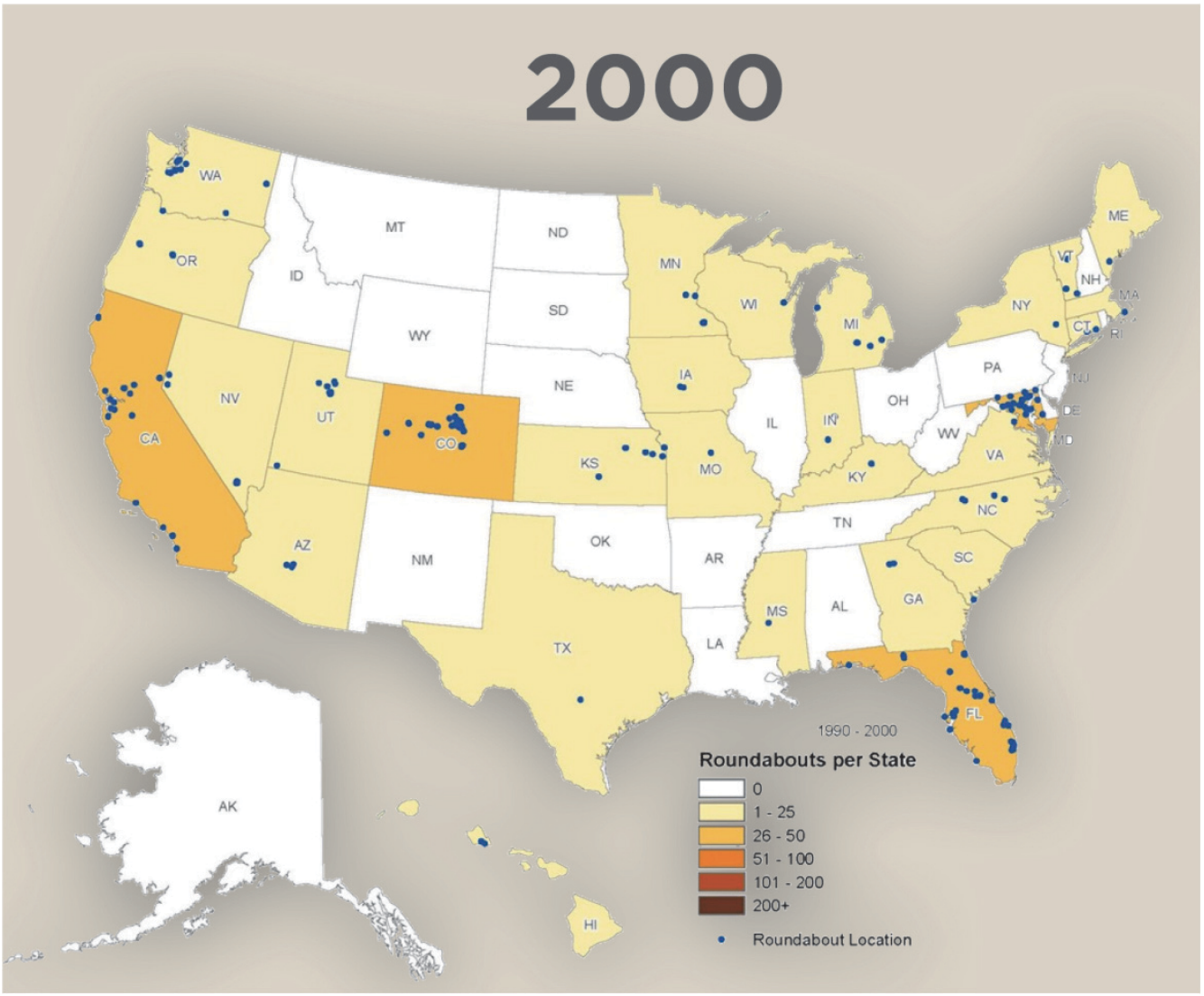


FIGURE 2 Location of roundabouts in the United States as of 2000. *Source*: Rodegerdts (2014) (*2*).

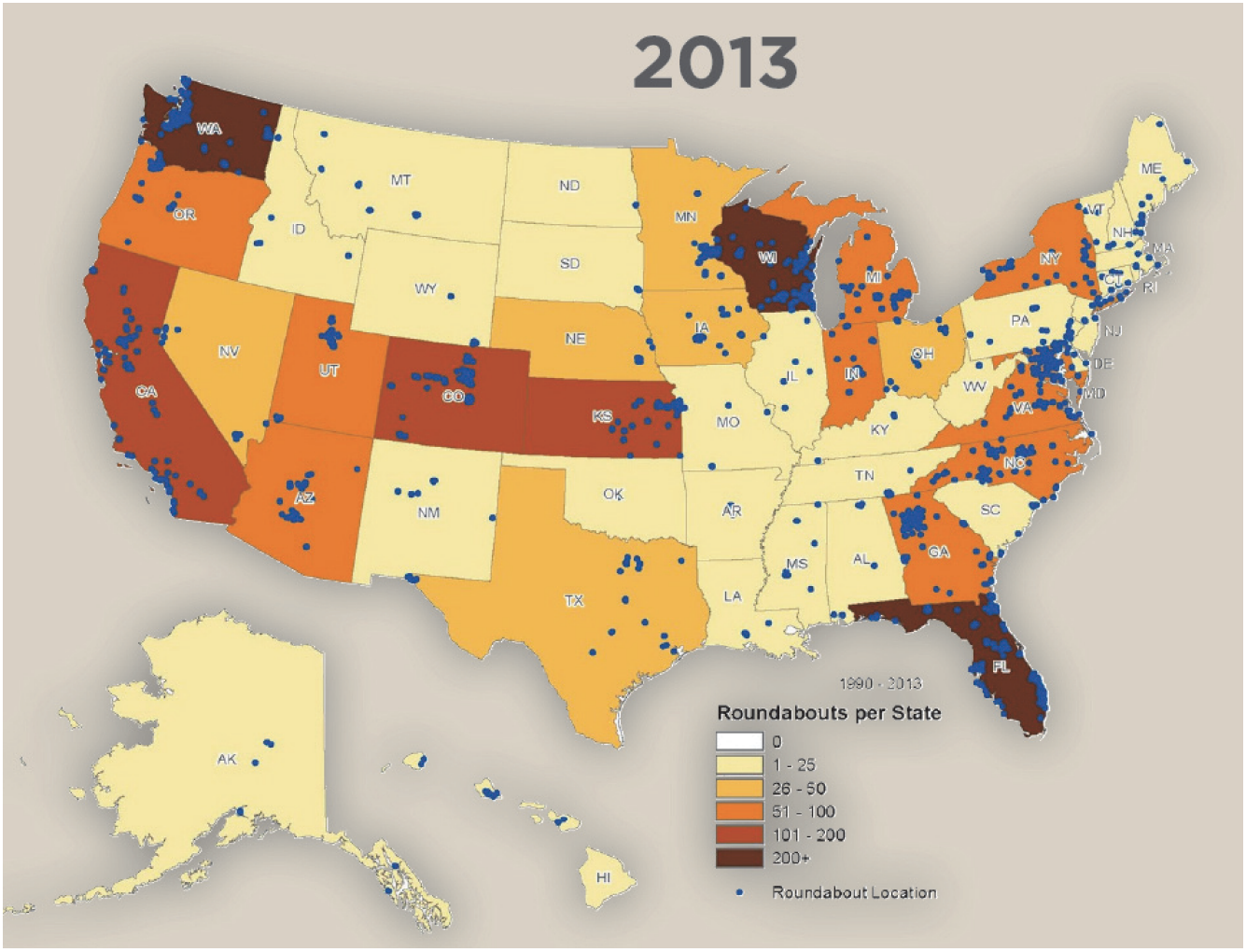


FIGURE 3 Location of known roundabouts in the United States as of 2013. *Source*: Rodegerdts (2014) (*2*).

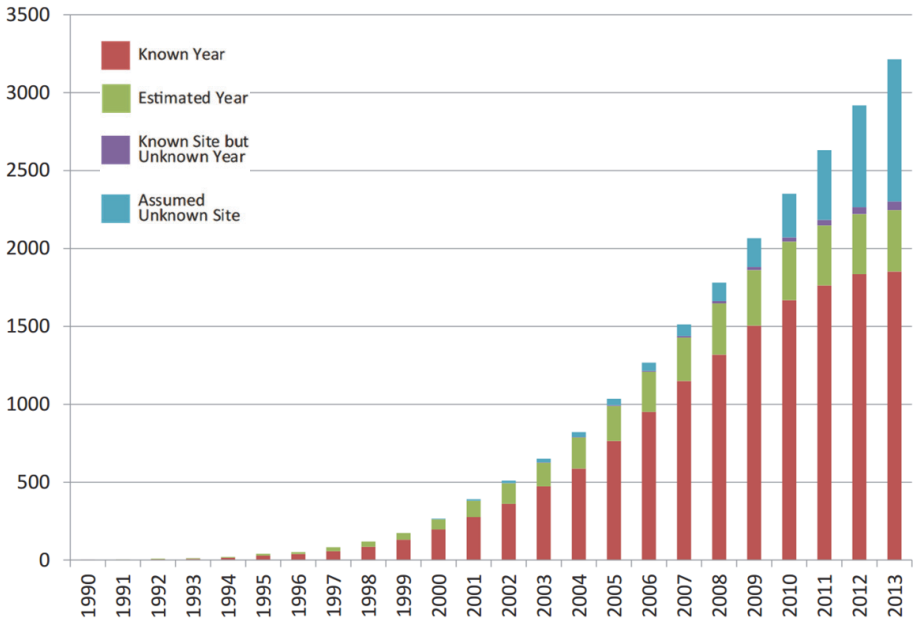


FIGURE 4 Estimated cumulative roundabouts in the United States. *Source*: Rodegerdts (2014) (*2*).

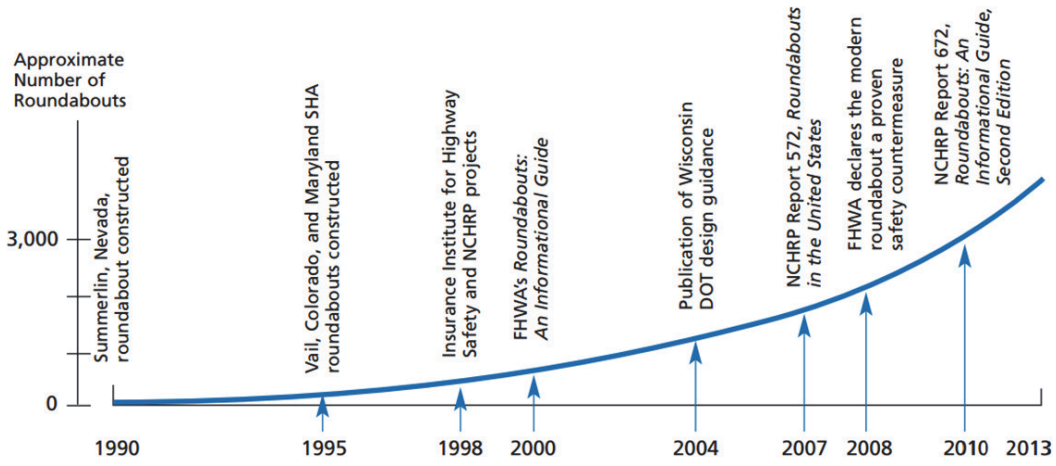


FIGURE 5 Timeline of roundabouts implementation and guidance development in the United States (*4*).

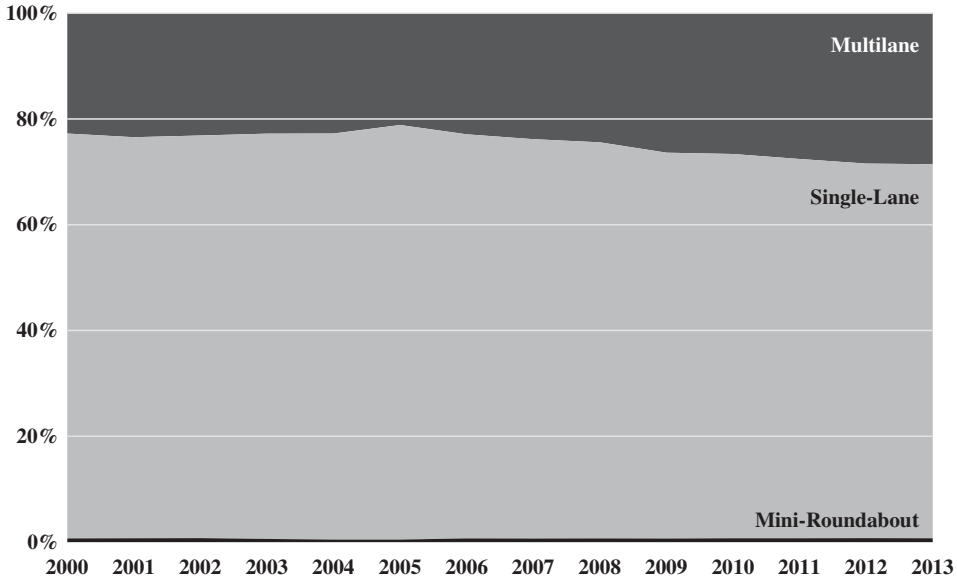


FIGURE 6 Cumulative percent of known roundabouts by type in the United States as of 2013. *Source*: Rodegerdts (2014) (*2*).

FIGURE 7 Mini-roundabout, Vierling Drive/County Road 79 intersection in Shakopee, Minnesota. *Source*: City of Shakopee (*7*).

FIGURE 8 Single-lane roundabout, 133rd Street/Lamar Avenue intersection in Overland Park, Kansas. *Source*: City of Overland Park, Kansas (*8*).

FIGURE 9 Multilane roundabout, SW Stafford Road/SW Borland Road intersection in Tualatin, Oregon. *Source*: Kittelson & Associates, Inc. (*9*).

FIGURE 10 Rochester roundabout, Brighton Avenue/Adams Street (SR-68)/Rhode Island Avenue (SR-18) intersection in Rochester Borough, Pennsylvania. *Source*: Whitman Requardt & Associates, LLP (*10*).

FIGURE 11 I-135/1st Street roundabout in Newton, Kansas. *Source*: Burns & McDonnell (*11*).

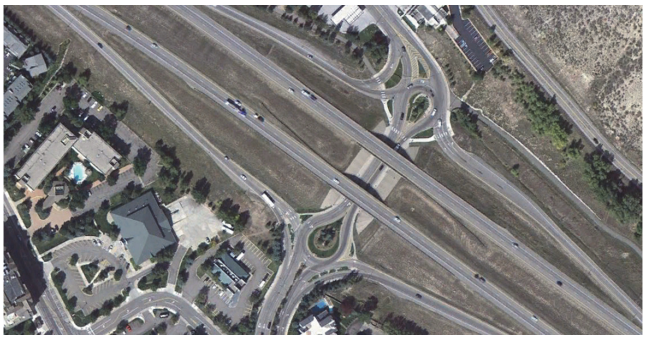


FIGURE 12 I-70/Avon Road roundabouts in Avon, Colorado. *Source*: Google (*12*).

Based on the categories displayed in Table 1, each state, along with the District of Columbia, was assigned to a group. Information from the 2010 review and assignment was updated for this synthesis. It can be noted that the categorization of roundabout policy type was somewhat subjective, especially in the division between "Allow" and "Encourage"—but was somewhat more straightforward in the difference between "Encourage" and "Evaluate," which was often as simple as the difference between "should" and "shall," respectively. An example of the policy text associated with each policy type category is given in Table 2, which lists example roundabout policy types from five states.

The number of states with each policy type was tabulated, and is displayed in Table 3. As shown, the most prevalent policy types were "Allow" and "Encourage," with 13 and 18 states, respectively. Currently, 13 states formally require the analysis of a roundabout alternative as denoted by the "Evaluate" and "Preferred" policy type categories. The remaining eight states have no formal or informal roundabout policy. The policy type categories were mapped in order to denote regional roundabout policy type trends (Figure 14).

The 2010 study on roundabout policies correlated the number of roundabouts in the state to the strength of the state-

FIGURE 13 Keystone Parkway/E 116th Street intersection in Carmel, Indiana. *Source*: Microsoft Corporation (*13*).

TABLE 1
TYPES OF ROUNDABOUT POLICIES

Category	Description
None	No policy or mention of roundabouts from the state DOT. Consequently, the state neither encourages nor discourages roundabouts.
Allow	The state allows the consideration of roundabouts.
Encourage	The state encourages the consideration of roundabouts.
Evaluate	The state requires the evaluation of a roundabout alternative.
Preferred	The state requires the evaluation of a roundabout, and justification when a roundabout is not the preferred alternative.

TABLE 2
EXAMPLE ROUNDABOUT POLICY TYPES

Policy Type	Sample Policy Text (Source)
None	N/A
Allow	A modern roundabout is an alternative form of intersection control to traffic signals and [multiway] stop control intersections. Therefore, roundabouts may be considered only when these intersection control types are warranted. (Kentucky)
Encourage	Those locations that meet or nearly meet [signal] warrants should be given consideration for roundabout installation. Intersections that are, or proposed to be, all-way stop controlled may also be good candidate locations for a roundabout. (Connecticut)
Evaluate	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: (1) Any intersection in a project that is being designed as new or is being reconstructed. (2) All existing intersections that have been identified as needing major safety or operational improvements. (3) All signal requests at intersections (provide justification in the Traffic Engineering Study if a roundabout is not selected). (Georgia)
Preferred	When the analysis shows that a roundabout is a feasible alternative, it should be considered the Department's preferred alternative as a result of the proven substantial safety benefits and other operational benefits. (New York)

N/A = Not Available.

wide roundabout policy (*14*). The study offered the following observations:

- An established policy typically indicates that a person or persons in leadership capacity are supportive of the policy.
- An established policy provides roundabout proponents with a position of influence within the agency by having regulatory backing.
- An agency with an established roundabout policy could indicate an organization open to change and innovation, which promotes an environment conducive to implementation.
- The enactment of a policy could indicate the breaking down of informal internal barriers, which otherwise could hinder the potential implementation.
- With more states enacting policies, new and revised policies have precedents for success.
- The implementation of a roundabout policy allows for the development of uniform and simplified procedures, standards, and regulations, thereby further increasing the chance for successful implementation of roundabouts.
- The establishment of roundabout policy validates roundabouts as an alternative.
- A policy helps to ensure the continuation of the roundabout program, especially when one of the early roundabout champions leaves the agency.
- The formation of a policy helps to institutionalize roundabouts in the state DOT's practice.

Several states have adopted intersection control evaluation (ICE) policies to provide a more proactive method for

TABLE 3
SUMMARY OF STATEWIDE ROUNDABOUT POLICIES

Policy Type	No. of States	%
None	7	14
Allow	13	25
Encourage	18	35
Evaluate	8	16
Preferred	5	10
Total	**51**	**100**

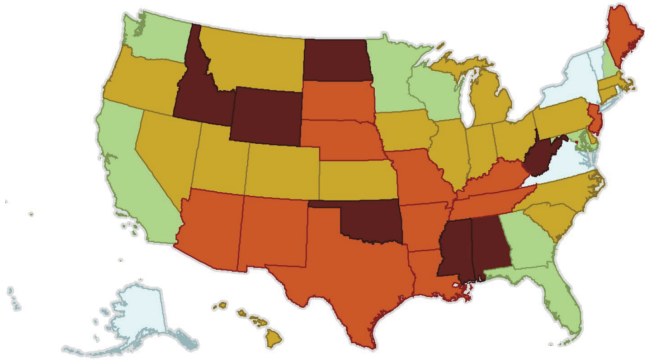


FIGURE 14 Roundabout policy type by state updated from the 2010 study (*14*).

evaluating intersection alternatives using performance-based design. Consequently, roundabouts are being considered earlier in the project development process, alongside other intersection treatments such as all-way stop-controlled intersections, signalized intersections, alternative intersection forms, and grade-separated forms. The ICE policies are helping to identify short- and long-term benefits that previously were not considered, including the evaluation of life-cycle costs (*4*).

STATE STATUTES, CODES, AND LAWS

The *Manual on Uniform Traffic Control Devices* (*MUTCD*) (*15*) requires a yield sign on all approaches to a roundabout. Section 2B.09 YIELD Sign Applications reads as follows:

> A YIELD (R1-2) sign shall be used to assign right-of-way at the entrance to a roundabout. YIELD signs at roundabouts shall be used to control the approach roadways and shall not be used to control the circulatory roadway.

If all roundabout approaches shall have a YIELD sign and all roundabout approaches operate under yield control, then all entering traffic must yield to circulating traffic regardless of whether or not a state has a specific statute, code, or law.

Nevada, like many other states, includes information in its *Driver's Handbook* (*16*), as shown in Figure 15.

PUBLIC OUTREACH EFFORTS

Although the safety and operational benefits of roundabouts are well documented, some states have been slow to build roundabouts. "A major impediment [to the construction of roundabouts] is the negative perception held by some drivers and elected officials" (*17*), which has been termed "roundabout anxiety" (*18*) or driver "angst" (*19*). In addition, confusion about the differences between roundabouts and rotaries, along with negative experience with rotaries, continues to linger (*20*). As has been demonstrated on countless occasions, the public in most jurisdictions will have a negative opinion of roundabouts before the installation of the first one (*21*). According to a telephone survey of Bellingham, Washington, area residents prior to the construction of a roundabout, only 36% of those surveyed were in favor (*22*); one year after construction, the percentage in favor of the roundabout increased to 70% (Figure 16). The Montana Department of Transportation (MDT) developed a synthesis report on education and outreach related to roundabouts (*23*), confirming public reluctance throughout the United States, and similarly finding that people remain skeptical until they have driven a roundabout.

Public outreach for roundabouts comes in many different formats. Some examples, though not a comprehensive list, are included in the *Roundabout Outreach and Education Toolbox* on the FHWA Office of Safety's website (*24*), which includes a range of options for public outreach, including websites, brochures, flyers, videos, and even coloring books. (The coloring book, developed by the city of Bend, Oregon, educates children on the basics of roundabouts, with a goal of demystifying the newer intersection type for a younger audience.) The Montana synthesis also provides an overview of education and outreach material used throughout the United States, with recommendations for when and where different outreach strategies may be appropriate.

Some states are providing information on how to navigate a roundabout: Figure 17 shows an example from the *Indiana Drivers Manual* (*25*). States are also using websites to communicate to the public. The South Dakota DOT (SDDOT) site (*26*) lists information on:

1. What is a roundabout
2. How to drive a roundabout
3. Roundabout benefits
4. Pedestrians and bicyclists.

A screenshot of the SDDOT roundabout website is shown in Figure 18, and a screenshot of the MDT roundabout website is shown in Figure 19.

ROUNDABOUT PERFORMANCE

This section documents methods used by state DOTs to determine the expected operational and safety performance of roundabouts.

Operational Performance

NCHRP Report 572: Roundabouts in the United States (*28*) provided the first roundabout capacity model anchored to empirically observed performance in the United States at a national level. The results of *NCHRP Report 572* were incorporated into the *Highway Capacity Manual 2010* (*29*). The *HCM 2010* procedure derives approach capacity from a regression-based analysis and also incorporates a calibration procedure using gap-acceptance parameters (*30*). Several jurisdictions have developed and documented calibration efforts, including the California DOT (Caltrans, *31*), city of Bend, Oregon (*32*), and the Kansas DOT (KDOT, *33*). The Wisconsin DOT (WisDOT) also recently completed a study evaluating the operational characteristics of roundabouts (*34*), and the city of Carmel, Indiana, developed a new model with higher capacities reflective of the local driver population (*35*).

Results from KDOT, WisDOT, and Georgia DOT (GDOT) (*36*) were within data ranges reported by *NCHRP Report 572*. However, the cities of Bend and Carmel have documented results indicating higher capacities on roundabouts in their communities, both of which have large concentrations of roundabouts. Table 4 shows a sample of capacity model calibration parameters.

Roundabouts

A roundabout is a large, circular area in the middle of an intersection meant to control the right-of-way of vehicles. It is a traffic management tool that moves traffic through an intersection without the aid of traffic signals.

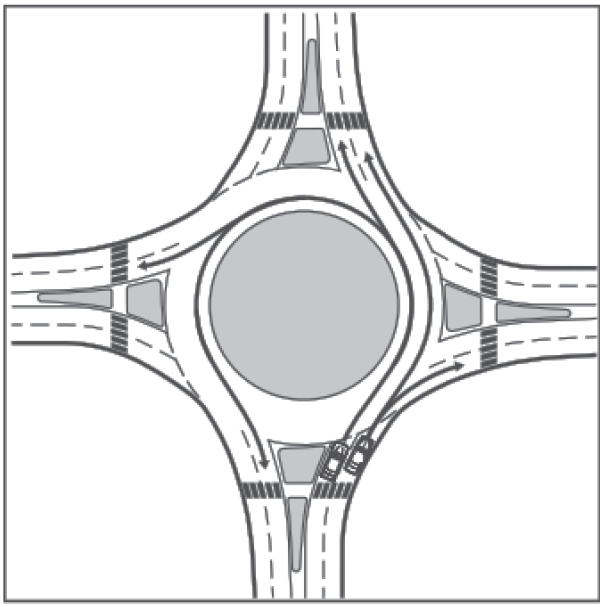
Entering traffic must yield the right-of-way to the traffic circulating within the roundabout. All traffic moves in ONE DIRECTION around the roundabout – COUNTERCLOCKWISE.

How to Drive in a Roundabout

1. As you approach, choose which lane to use as you would for any other intersection.
2. Use the left lane to turn left, complete a U-turn or go straight. Use the right lane to turn right or go straight.
3. Yield. Those in the roundabout have the right-of-way. Wait for a gap in the traffic.
4. Decrease your speed to travel with the traffic already in the roundabout.
5. Use your right turn signal when exiting.

Trucks:

1. Drive on the circulatory roadway, except large commercial trucks and trailers are permitted to use the truck apron provided around the center island to negotiate the tight turning radius.
2. Drive (usually with just the rear wheels) on the raised pavement of the truck apron to navigate more easily.
3. Cars should not use the truck apron.



Bicyclists:

1. If you are comfortable riding in traffic, take the lane and circulate with the vehicles, making sure to yield to traffic in the circle when entering.
2. Ride at the speed of the circular roadway to discourage cars from wanting to pass you.
3. Use hand signals when exiting the roundabout.
4. If you are unsure about using the roundabout, dismount and walk your bike in the designated crosswalks.

Pedestrians:

1. Stay in the designated crosswalks at all times.
2. Never cross to the central island.
3. Watch for cars; you have the right-of-way, but always pay attention.

FIGURE 15 Roundabout guidance in the *Nevada Driver's Handbook* (*16*).

As of the writing of this synthesis, FHWA is leading a study to update the capacity equations. The results of this research are expected to be published in 2016. Preliminary results presented at the TRB 4th International Roundabout Conference in 2014 (*37*) indicate roundabouts are operating at greater capacities than estimated by the *HCM 2010* model based on the *Appendixes to NCHRP Report 572* (*38*). Initial results indicate geometric effects such as inscribed circle diameter, entry lane width, entry angle, and splitter island width are not strong enough to include in the capacity model. Furthermore, the exponential form, consistent with the model form in *NCHRP Report 572*, fits the same or better than other linear forms.

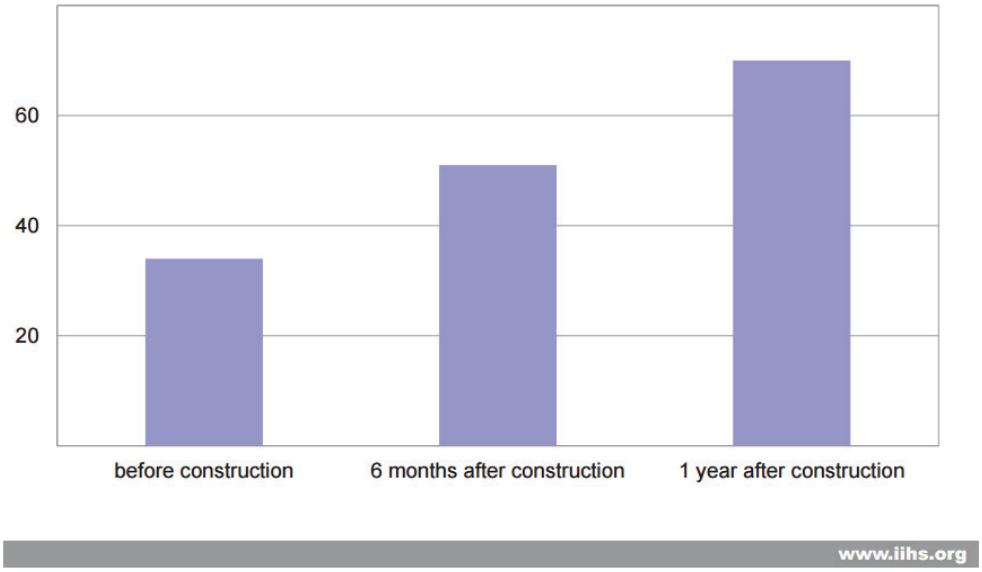
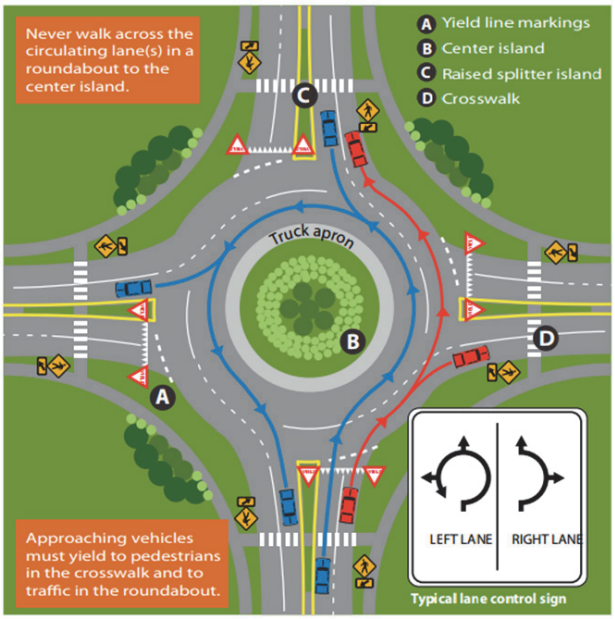


FIGURE 16 Percent of drivers who support roundabouts—Telephone surveys of Bellingham, Washington, area residents (*22*).

Roundabouts

A roundabout is a circular intersection in which traffic enters or exits only through right turns and proceeds in a counter-clockwise direction. When approaching a round-about incoming traffic always yields to the circulating traffic.



Two-lane roundabout
(does not reflect all roundabout designs)

For multilane roundabouts where the circular roadway has more than one (1) lane, drivers should know which lane they need to be in prior to entering the roundabout. Drivers should not change lanes in the circulatory roadway. Signs, pavement markings, or both, are provided to guide drivers to the proper lane in advance of the circulatory roadway.

A traffic circle differs from a roundabout in that it may have clockwise and counter-clockwise traffic. The approaches to the circulatory roadway of a traffic circle may also be controlled by stop signs instead of yield signs.

FIGURE 17 Roundabout explanation in the *Indiana Drivers Manual* (*25*).

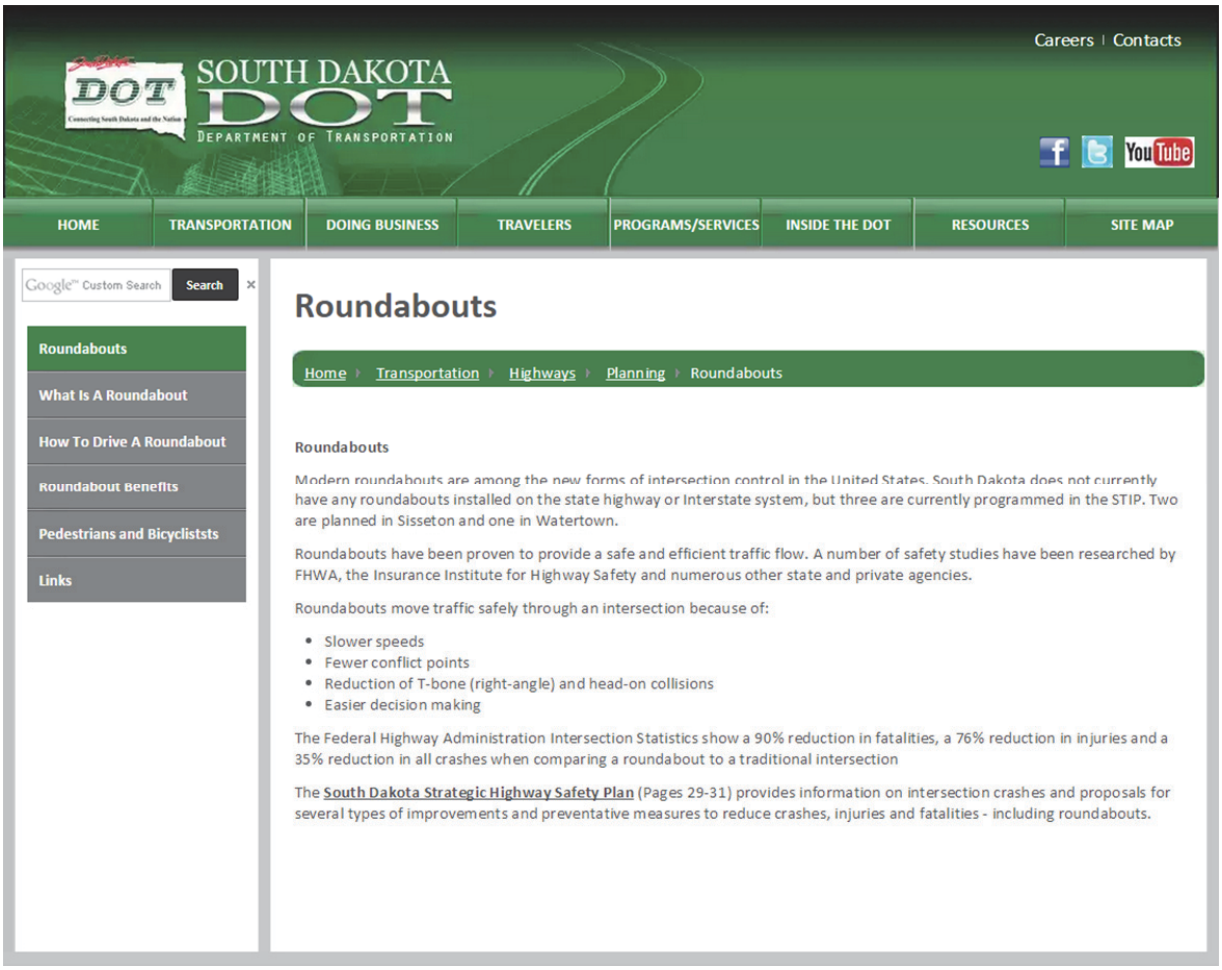


FIGURE 18 South Dakota Department of Transportation Roundabouts website (*26*).

Roundabouts in Corridors

NCHRP Report 772: Evaluating the Performance of Roundabouts in Corridors (*30*), published in 2014, studied nine roundabout corridors in the United States. As a result of the study, a methodology for estimating travel speed was developed for inclusion in the *HCM*. The study identified "a need for corridor-specific evaluation to determine which form of intersection control is preferred on a given corridor." Lastly, a corridor comparison document (CCD) was developed to provide a framework for comparing the performance of a corridor with roundabouts to a corridor with signalized intersections or other intersection treatments to arrive at a design solution. The CCD includes information on different corridor users, typical performance measures, and examples illustrating the use of the CCD.

Roundabout Analysis

A 2012 report, *Roundabout Software Evaluation* (*39*), evaluated software tools available for analyzing roundabout capacity. The report found that "a software package that has the capability of performing capacity analysis using U.S. based models is desirable." The report did not recommend a particular software package or packages, but instead clarified that "many other considerations, unique to each agency, are required in order to arrive at a recommendation for a software package." The report provided an evaluation matrix to aid in decision making.

ROUNDABOUT DESIGN

Although the first roundabout built in the U.S. opened in 1990, the first state DOT design guidance documents were not developed for several years, with Maryland State Highway Administration (SHA) and Florida DOT publishing documents in 1995 and 1996, respectively. The first federal design guide, *NCHRP 672: Roundabouts: An Informational Guide* (*40*), followed in 2000. To date, there are still state DOTs that have not incorporated roundabout design into their design manuals and guidance. *NCHRP Report 672: Roundabouts: An Informational Guide*, 2nd Edition (*6*), was published in 2010, and officially adopted by FHWA as the second edition of the federal guide.

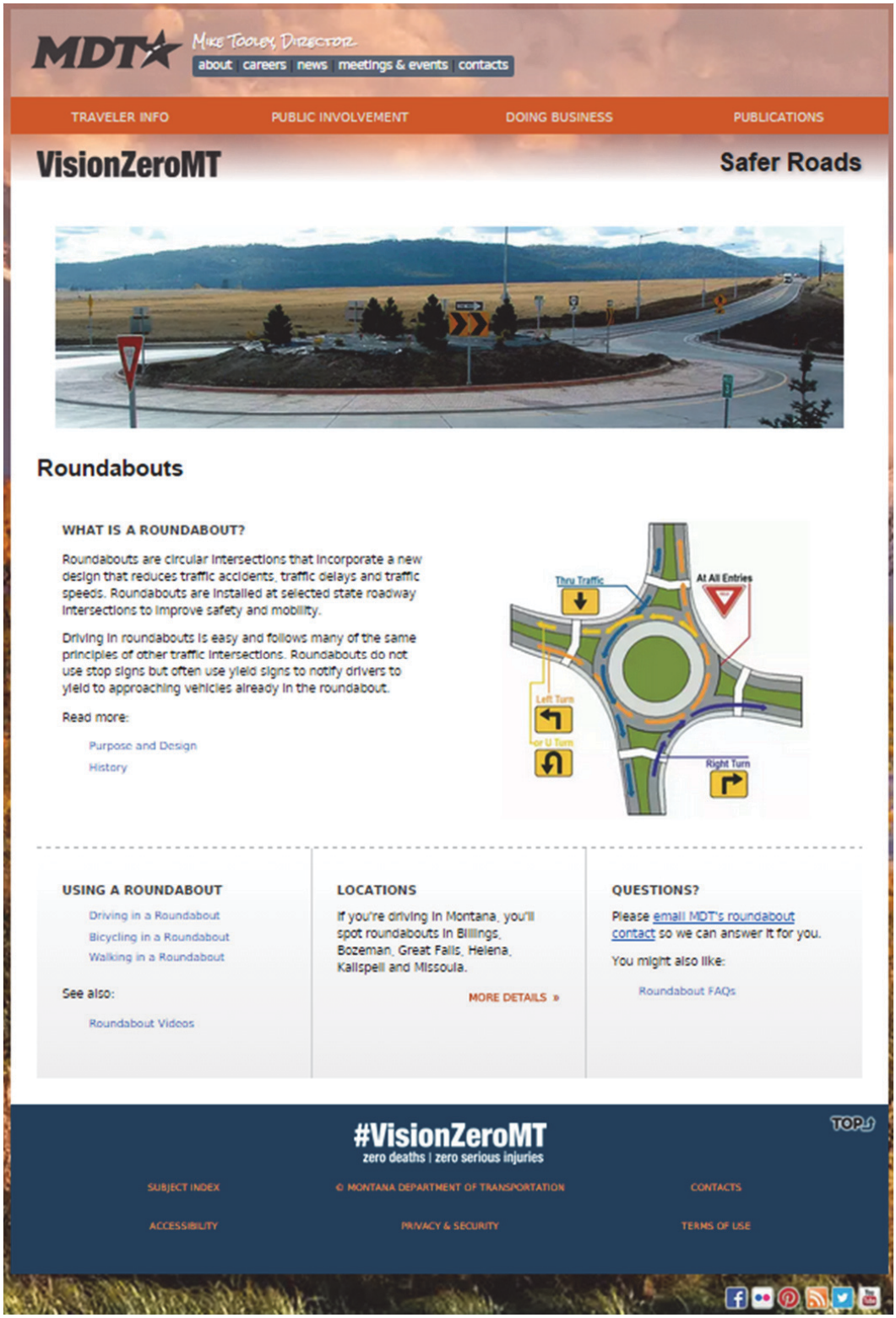


FIGURE 19 Montana Department of Transportation Roundabouts website (*27*).

TABLE 4
SUMMARY OF CRITICAL HEADWAY AND FOLLOW-UP HEADWAY FACTORS

Calibration Parameter		*NCHRP Report 572* (*28*)* (Nationwide 2007)	Bend Roundabout Guide (*32*) (Bend, Oregon 2010)	Caltrans Roundabout Guide (*31*) (California 2007)	Developing Capacity Models for Local Roundabouts (*35*) (Carmel, Indiana 2011)	Wisconsin Roundabout Evaluation (*34*) (Wisconsin 2011)	Georgia Calibration (*36*) (Georgia 2013)
Single-Lane Roundabouts							
Critical Headway		5.1 s	4.1	4.5–5.3 s	3.4–3.8 s	4.8–5.5 s	4.75 s
Follow-up Headway		3.2 s	2.7	2.3–2.8 s	2.1–2.4 s	2.6–3.8 s	3.27 s
Multilane Roundabouts							
Critical Headway	Left lane	4.5 s	—	4.4–5.1 s	—	4.1–4.8 s	—
	Right lane	4.2 s	—	4.0–4.8 s	—	3.4–4.4 s	—
Follow-up Headway	Left lane	3.4 s	—	1.8–2.7 s	—	2.5–3.1 s	—
	Right lane	3.1 s	—	2.1–2.3 s	—	2.2–3.0 s	—

*Results from Kansas are similar to *NCHRP Report 572* (*33*).
— = Not Reported.

Although some states make reference to *NCHRP Report 672* for design guidance, other states go further than just referring to the federal guidance and include some material in their own manual or online, such as what is found in Maryland's *Roundabout Design Guidelines* (*41*):

> The Maryland State Highway Administration (SHA) has adopted the NCHRP Report 672: Roundabouts: An Informational Guide, Second Edition as our Roundabout Design Guideline. The information contained in this document is considered a Supplement to the NCHRP Report 672 and is intended to document SHA's approach to the design of roundabouts.

Other states have developed standalone design guidance. For instance, the *Kansas Roundabout Guide*, 2nd Edition (*42*) states:

> This guide is intended to provide practitioners and the general public with information and guidance related to roundabouts in the State of Kansas and serve as a companion to NCHRP Report 672: Roundabouts: An Informational Guide, 2nd Edition.

Design Vehicle Accommodations

The type and size of vehicle that will use the roundabout affects the design of the intersection, as with other intersection forms. For example, the Georgia DOT *Roundabout Design Checklist* (*43*) states:

> It should be recognized that unlike conventional intersection forms (e.g., signalization, stop control, etc.) the configuration and layout of a roundabout can be dramatically affected by the results of capacity, fastest path, and truck turning template studies and thus often requires higher level of engineering during the concept phase.

Although accommodating larger vehicles is important, there are other factors to consider. Concerning the percentage of trucks at a roundabout, Washington State DOT (WSDOT) guidance suggests, "Designers should also recognize that among that percentage, WB-67s may only represent a small sample of the entire truck volume on any given day." WSDOT's guidance allows trucks to encroach on adjacent lanes with the intent to reduce the overall size of the intersection. Figure 20 shows an example of this design technique for both roundabouts and signalized intersections.

Illumination

Illumination at roundabouts is provided for safety and operations. Very few states have their own unique guidance on illumination at roundabouts. For instance, the Kansas Roundabout Guide draws from resources including *NCHRP Report 672*, which relied on the *Design Guide for Roundabout Lighting* written by the Illuminating Engineering Society (IES). AASHTO also provides illumination guidance in the *Roadway Lighting Design Guide.*

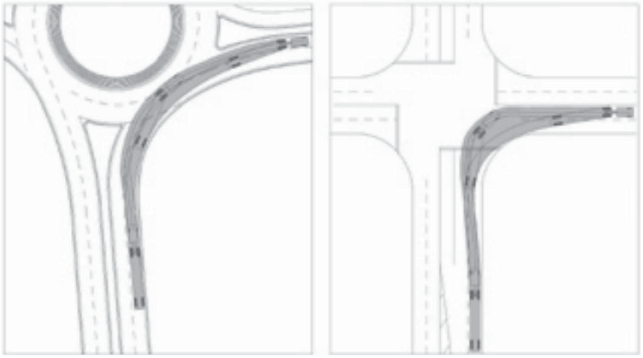


FIGURE 20 WB-65 Right-Turn Movement Over-Tracking Comparison (*44*).

CHAPTER THREE

SURVEY RESULTS

This chapter outlines the results of the background information collected in a survey of all state agencies across the United States. The information was gathered from responses to a survey questionnaire distributed to all members of the AASHTO Subcommittee on Traffic Engineering, which includes the state traffic engineers from the 50 states as well as Washington, D.C. and Puerto Rico. The survey was sent in February 2015, with follow-up reminders sent in March and April. Forty (40) states, or 80%, responded to the survey, as shown in Figure 21.

The survey was modeled on portions of the 1998 *NCHRP Synthesis 264* report, and where applicable, the results are compared. Although *NCHRP Synthesis 264* recorded responses from 44 state agencies, only nine reported a roundabout in operation, under construction, or in design as of 1997. Of the 40 states that responded to the questionnaire for this effort, two states (Idaho and South Dakota) reported that their agency has not built a roundabout on the state highway system. However, SDDOT reported that a roundabout has been planned or designed, but not yet built. (As discussed in the literature review chapter, all 50 states and the District of Columbia had a roundabout as of 2010, but some did not have a roundabout built under the purview of the state agency or the state highway system.)

The data received in the *NCHRP Synthesis 264* questionnaire also included specific information about individual roundabouts in operation by state agencies and municipalities. Because of the larger number of roundabouts now in operation in the United States, this information was not replicated as part of this synthesis.

To assess when individual states began constructing roundabouts, respondents were asked the approximate year the state agency built its first roundabout on the state highway system, *not* the year the first roundabout was constructed in their state. In some cases, respondents reported the year the first circular intersection was built on the state highway system. In these cases, the online database maintained by Kittelson & Associates, Inc. (*3*). was consulted to identify the appropriate year. As shown in Figure 22, six state agencies had built roundabouts before 1999. By 2000, more than twice as many state agencies had built roundabouts (14 total), and by 2012, 38 of the 40 reporting state agencies had built a roundabout.

States were asked to provide the approximate total number of mini-, single-lane, and multilane roundabouts in their state, and the approximate number of mini-, single-lane, and multilane roundabouts that their state has jurisdiction over and/or were built as part of projects overseen by their state agency on the state highway system. Table 5 displays the approximate total number of roundabouts, by type, as reported by each state responding to the questionnaire, and Table 6 displays the approximate total number of roundabouts on the state highway system, by type, as reported by each state. (The numbers of roundabouts provided by the states may differ from information included in the literature review in chapter two. Further, although this survey included definitions describing each type of roundabout, states may have interpreted terms differently.)

As seen, the total number of roundabouts for all of the reporting states is approximately 2,707, with 1,997 single-lane roundabouts (74%) and 616 multilane roundabouts (26%). Washington and Wisconsin both report having more than 300 total roundabouts, while Missouri, North Carolina, and Washington each report having more than 200 single-lane roundabouts. Wisconsin is the only state reporting more than 100 multilane roundabouts, and is also the only state where the reported number of multilane roundabouts is more than half of the number of total roundabouts.

Concerning roundabouts on a state highway system, Wisconsin is the only state reporting more than 200 in total; North Carolina, Virginia, and Wisconsin each report having 100 or more single-lane roundabouts on the state highway system. Wisconsin reports 147 multilane roundabouts on the state highway system; the next highest reported number, 30, is in Washington.

Approximately 45% of the total roundabouts reported are on the state highway system. Approximately 42% of the reported single-lane roundabouts are on the state highway system, and approximately 60% of the reported multilane roundabouts.

The states were asked to provide the environment (urban, suburban, or rural) in which mini-, single-lane, and multilane roundabouts were located in their states. The responses were generalized—all, some, most, or none—in an attempt to increase the response rate; and were converted to a numerical score using a value of 1 for all, 0.67 for some, 0.33 for some, and 0 for none. Figure 23 is a visual representation of the proportion of mini-, single-lane, and multilane roundabouts in urban, suburban, and rural locations. As shown, the most common reported environment for all roundabout types is urban, with suburban environments also common for single-lane and multilane roundabouts. A higher proportion of mini-roundabouts are located in urban areas compared with

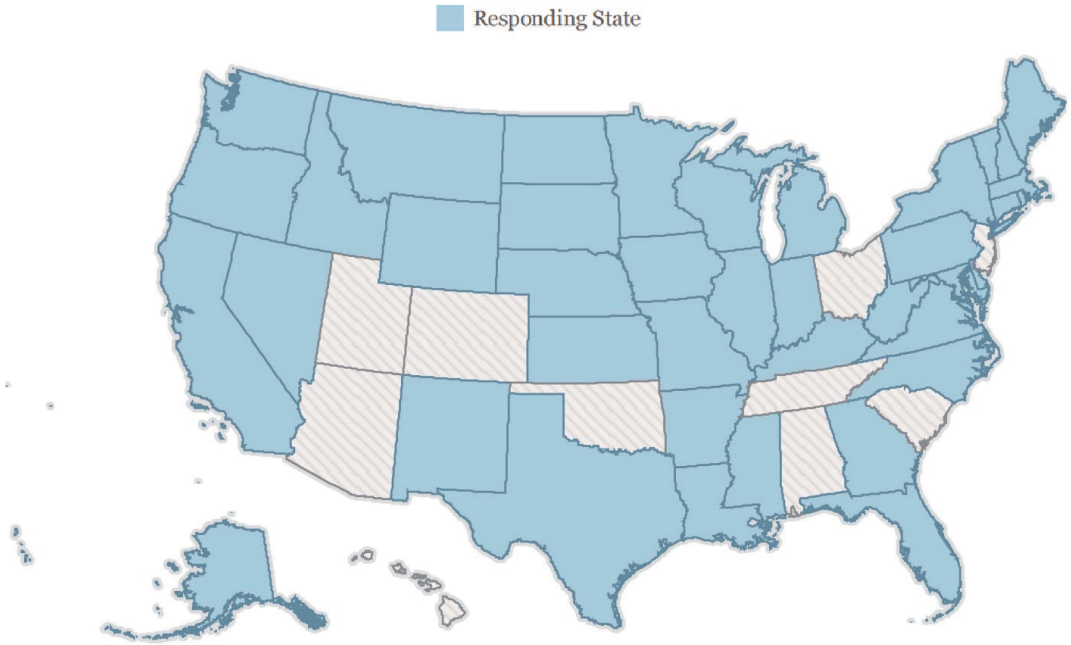


FIGURE 21 States responding to questionnaire.

single-lane and multilane roundabouts. Rural roundabouts are most likely to be single-lane roundabouts.

ROUNDABOUT SELECTION

States were asked to select the frequency in which they select roundabouts based on a set of common reasons, items from *NCHRP Synthesis 264* supplemented by reasons identified by the study team and the panel for this synthesis. The following reasons of selection were provided, and states were asked to provide the frequency using a Likert-type rating scale—always, usually, about half the time, seldom, and none—of responses:

- Aesthetic/urban design improvements
- Higher capacity
- Improved safety performance
- Lower initial capital costs
- Lower life-cycle costs
- Lower speeds/traffic calming
- Responding to request from elected official
- Responding to request from local jurisdiction
- Shorter vehicular delays.

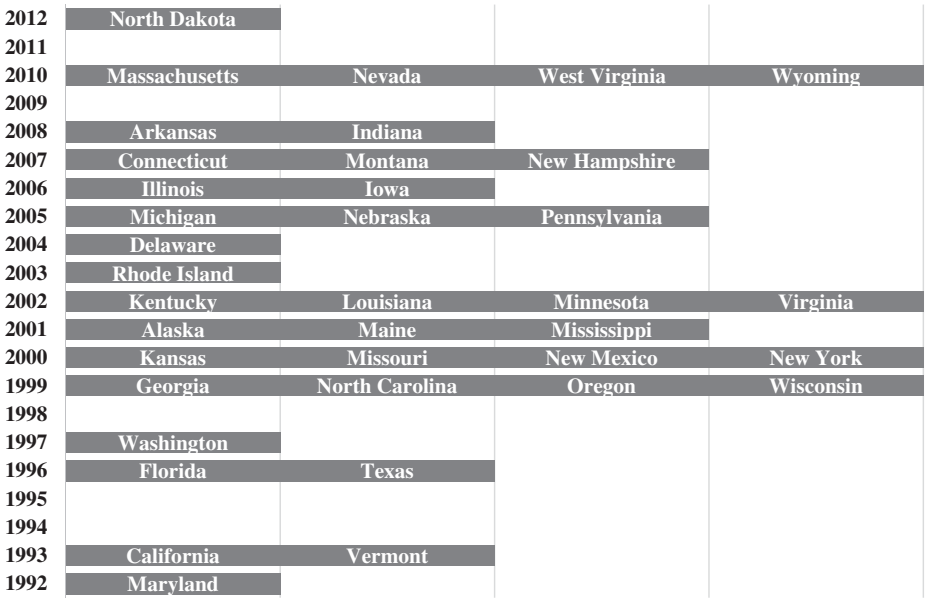


FIGURE 22 Year state agency built their first roundabout on the state highway system.

TABLE 5
APPROXIMATE REPORTED TOTAL NUMBER OF ROUNDABOUTS WITHIN EACH REPORTING STATE

	Reported Total Mini-Roundabouts	Reported Total Single-Lane Roundabouts	Reported Total Multilane Roundabouts	**Reported Total Roundabouts**
Alaska	3	20	9	**32**
Arkansas	0	25	0	**25**
California	No answer	253	44	**297**
Connecticut	2	20	2	**24**
Delaware	1	11	1	**13**
Florida	4	13	11	**28**
Georgia	3	130	2	**135**
Idaho	No answer	No answer	No answer	**—**
Illinois	No answer	No answer	No answer	**—**
Indiana	0	122	39	**161**
Iowa	10	37	9	**56**
Kansas	No answer	77	34	**111**
Kentucky	0	10	1	**11**
Louisiana	No answer	No answer	No answer	**—**
Maine	No answer	19	5	**24**
Maryland	10	114	37	**161**
Massachusetts	No answer	No answer	No answer	**—**
Michigan	1	50	30	**81**
Minnesota	2	107	32	**141**
Mississippi	30	20	6	**56**
Missouri	5	200	20	**225**
Montana	1	20	12	**33**
Nebraska	No answer	6	4	**10**
Nevada	No answer	10	4	**14**
New Hampshire	0	28	6	**34**
New Mexico	No answer	15	15	**30**
New York	2	100	25	**127**
North Carolina	0	229	18	**247**
North Dakota	10	2	No answer	**12**
Oregon	0	60	10	**70**
Pennsylvania	0	20	1	**21**
Rhode Island	No answer	3	3	**6**
South Dakota	No answer	3	0	**3**
Texas	No answer	No answer	No answer	**—**
Vermont	1	12	1	**14**
Virginia	No answer	145	15	**160**
Washington	9	210	85	**304**
West Virginia	0	5	4	**9**
Wisconsin	0	154	175	**329**
Wyoming	No answer	No answer	No answer	**—**
Total	**94**	**2,250**	**660**	**3,004**

The number of roundabouts shown are numbers provided by each reporting state, and may differ from information included in the Literature Review section of this synthesis.
— = Not Reported.

States were also asked to provide additional reasons why roundabouts were selected in a comment field. Figure 24 displays the most frequent reasons for the selection of roundabouts by state agencies. To provide a visual representation of the frequency of selection, a weighted score was applied to the responses using a value of 1 for always, 0.75 for usually, 0.5 for about half the time, 0.25 for seldom, and 0 for never.

As shown, the primary reason for the selection of roundabouts is improved safety performance, selected with "always" or "usually" frequency by 33 of the 37 responses (89%). By comparison, 22% of respondents in *NCHRP Synthesis 264* indicated "greater safety" as a major reason for building roundabouts. Shorter vehicular delays and higher capacity were the next most frequent responses, with 68% and 51% of respondents choosing "always" or "usually," respectively. Several respondents indicated that the two answers could be combined, but they were separated to provide a comparison with *NCHRP Synthesis 264*, where 14% and 8% of respondents chose "shorter delays" and "higher capacity," respectively.

On the other end of spectrum, the most frequent reasons that were cited as "seldom" (69%) or "never" (78%) for selecting roundabouts are "lower initial capital costs" and "responding to a request from elected official."

Several states provided written comments indicating other reasons why roundabouts were being considered. These responses included directives from the state agency to consider roundabouts, and the ability to minimize right-of-way impacts between intersections on narrow corridors or bridges.

TABLE 6
APPROXIMATE REPORTED TOTAL NUMBER OF ROUNDABOUTS ON THE STATE HIGHWAY SYSTEM WITHIN EACH REPORTING STATE

	Reported Mini-Roundabouts on the State Highway System	Reported Single-Lane Roundabouts on the State Highway System	Reported Multilane Roundabouts on the State Highway System	**Reported Total Roundabouts on the State Highway System**
Alaska	0	11	7	**18**
Arkansas	0	0	4	**4**
California	0	11	12	**23**
Connecticut	0	3	1	**4**
Delaware	1	11	1	**13**
Florida	0	11	3	**14**
Georgia	2	20	0	**22**
Idaho	No answer	No answer	No answer	**—**
Illinois	No answer	No answer	No answer	**—**
Indiana	0	5	9	**14**
Iowa	0	7	0	**7**
Kansas	0	13	7	**20**
Kentucky	No answer	9		**9**
Louisiana	0	22	1	**23**
Maine	No answer	19	5	**24**
Maryland	1	53	24	**78**
Massachusetts	0	4	2	**6**
Michigan	0	10	15	**25**
Minnesota	0	24	9	**33**
Mississippi	0	3	3	**6**
Missouri	1	55	15	**71**
Montana	0	10	10	**20**
Nebraska	No answer	6	2	**8**
Nevada	No answer	4	No answer	**4**
New Hampshire	0	8	1	**9**
New Mexico	No answer	10	10	**20**
New York	0	65	25	**90**
North Carolina	0	120	16	**136**
North Dakota	No answer	1	No answer	**1**
Oregon	0	1	1	**2**
Pennsylvania	0	17	1	**18**
Rhode Island	No answer	No answer	No answer	**—**
South Dakota	0	0	0	**0**
Texas	No answer	No answer	No answer	**—**
Vermont	0	6	1	**7**
Virginia	No answer	110	5	**115**
Washington	4	80	30	**114**
West Virginia	0	0	4	**4**
Wisconsin	0	100	147	**247**
Wyoming	0	5	0	**5**
Total	**9**	**834**	**371**	**1,214**

The number of roundabouts shown are numbers provided by each reporting state, and may differ from information included in the Literature Review section of this synthesis.
— = Not Reported.

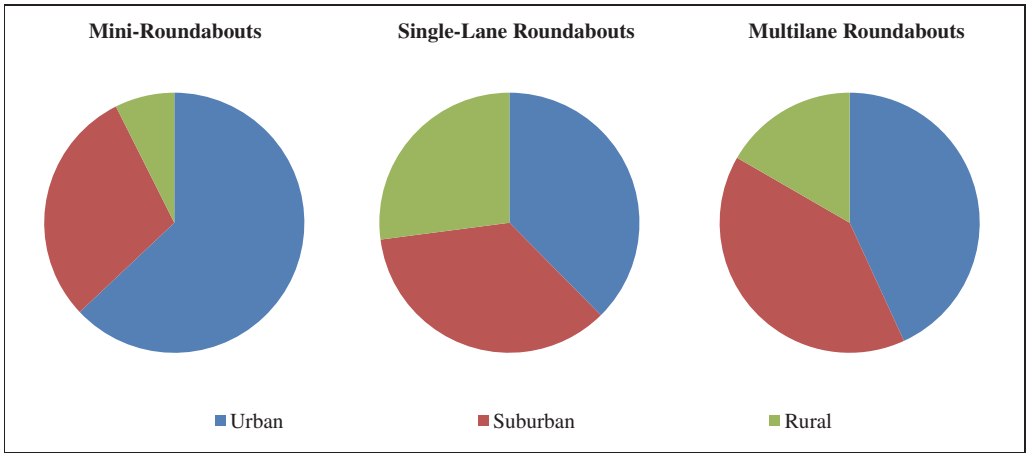


FIGURE 23 Approximate reported proportion of roundabouts by location and type.

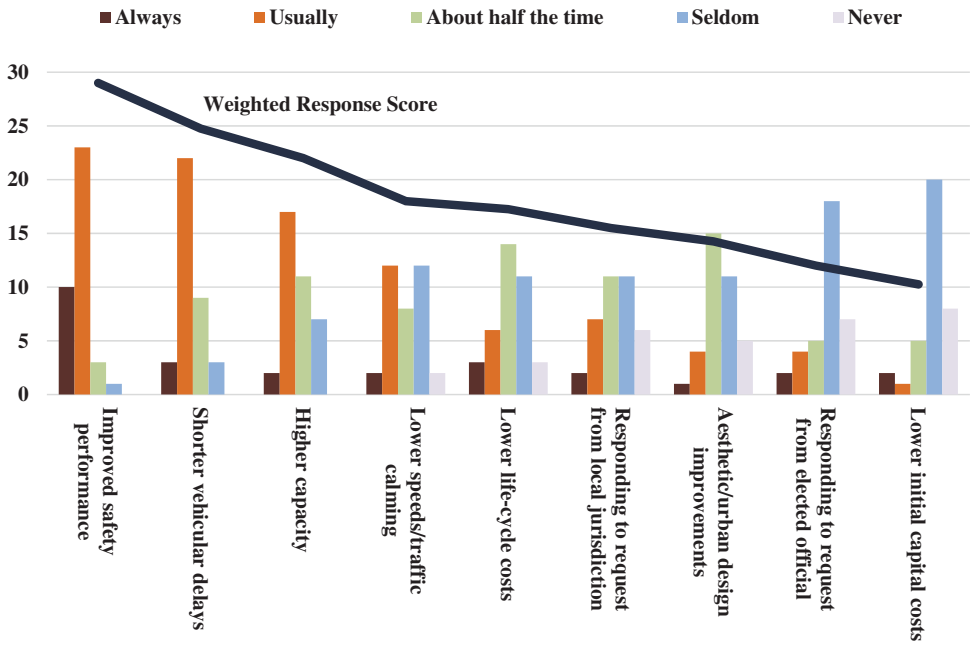


FIGURE 24 Number of responses indicating the frequency of the use of primary reasons for the selection of roundabouts.

As with *NCHRP Synthesis 264*, state agencies that had not built a roundabout were asked to provide reasons. Because only one state agency had not built or planned to build a roundabout, compared with 35 state agencies in *NCHRP Synthesis 264*, the results are less meaningful. However, the one state did indicate it was considering the construction of roundabouts, whereas *NCHRP Synthesis 264* reported only 30% of states without a roundabout in the state system were considering their construction.

States were also asked whether their state agency had installed a roundabout in a location that had previously experienced one or more fatal crashes; as shown in Table 7, 23 of the 38 (61%) responded affirmatively.

TABLE 7
STATE AGENCIES THAT INSTALLED A ROUNDABOUT AT A LOCATION THAT HAD PREVIOUSLY EXPERIENCED ONE OR MORE FATAL CRASHES

Response	Number	%
Yes	23	61
No	8	21
Don't know	7	18
Total	**38**	**100**

ROUNDABOUT COSTS

States provided the approximate planning-level cost estimate (for use in a screening or feasibility level estimate) for mini-, single-lane, and multilane roundabouts in their states, and asked to limit their responses to "single-purpose" intersection projects. The planning-level cost estimate was intended to provide an estimate for the total cost for opening a roundabout. However, it is possible that states may have misinterpreted the question, and provided only the construction cost rather than the total cost including the planning, design, and construction of the roundabout.

As shown in Table 8, the states' planning estimates for a mini-roundabout range from $50,000 to $1 million, with an average of $249,000. The planning-level cost estimates reported by states for a single-lane roundabout is higher, ranging from $100,000 to $5 million, with an average of $1.30 million. Highest are the costs of multilane roundabouts, estimated at $200,000 and $6 million, with an average of $2.05 million.

PUBLIC OUTREACH

States were asked to list the types of public outreach materials they have developed, and the results are shown in Figure 25. The question did not specify whether the public outreach material was project related or for general education purposes. As shown, 30 of the 39 reporting states (77%) have developed a roundabout website, 33 (85%) have developed a flyer and/or pamphlet, and 21 (54%) have developed a video. States were also asked to list other types of public outreach they had developed. Several states responded by saying they had included guidance about roundabouts on state highway maps, and several also mentioned TV and radio commercials and video animations. Lastly, one state also added newspaper articles and roundabout information included in the state's commercial drivers manual, and another state added that it has used a mall kiosk, bus rides, and simulator events. Four

TABLE 8
PLANNING LEVEL COST ESTIMATE (SCREENING OR FEASIBILITY LEVEL ESTIMATE) BY ROUNDABOUT TYPE AS REPORTED BY STATE AGENCY

	Roundabout Type		
	Mini-roundabout	**Single-lane roundabout**	**Multilane roundabout**
Number of Responses	10	29	25
Minimum	$50,000	$100,000	$200,000
Average	$249,000	$1,296,034	$2,048,000
Maximum	$1,000,000	$5,000,000	$6,000,000

of the reporting states (10%) indicated they had not developed any public outreach material.

As shown in Table 9, nearly all the states—37 of 38—use public information open houses, and over half use all of the strategies listed. In particular, states that use public information open houses list "attendance from agency staff." Over 90% of the states include traffic engineers involved in the project, and 95% of the states prepare a presentation.

ROUNDABOUT PERFORMANCE ANALYSIS

This section provides an overview of the methods used by state DOTs to analyze the operational performance of roundabouts, and those used to analyze their safety performance.

Operational Performance Analysis

The states provided the operational performance analysis model(s) used or permitted by their state agencies. As shown in Table 10, 26 of the 36 states responding to the question (72%) use at least one form of the *HCM 2010* model, with 22 states using the base *HCM 2010* model and 12 states using the *HCM 2010* model calibrated to local conditions. At least one form of the SIDRA Standard model is used by 27 of the 36 states responding to the question (75%), with 20 states using the SIDRA Standard model with the environment factor, and 13 states using the model without the environment factor. Eight of the reporting states use United Kingdom (UK) equations, with four states using equations that are not calibrated to local conditions, and four using UK equations that are calibrated to local conditions. Some form of microsimulation is used by 22 of the 36 reporting states (61%).

The states also provided information on the software tools used by their state agency to determine the operational performance of a roundabout. The list of software tools was taken from the *Roundabout Software Evaluation* (*39*) report, with non-English language software tools removed, and new software tools available since the report was published added. As shown in Table 11, SIDRA is the most widely-used software tool, used by 28 of the 37 state agencies responding to the question, followed by Synchro and HCS. In addition to commercially available software packages, several states

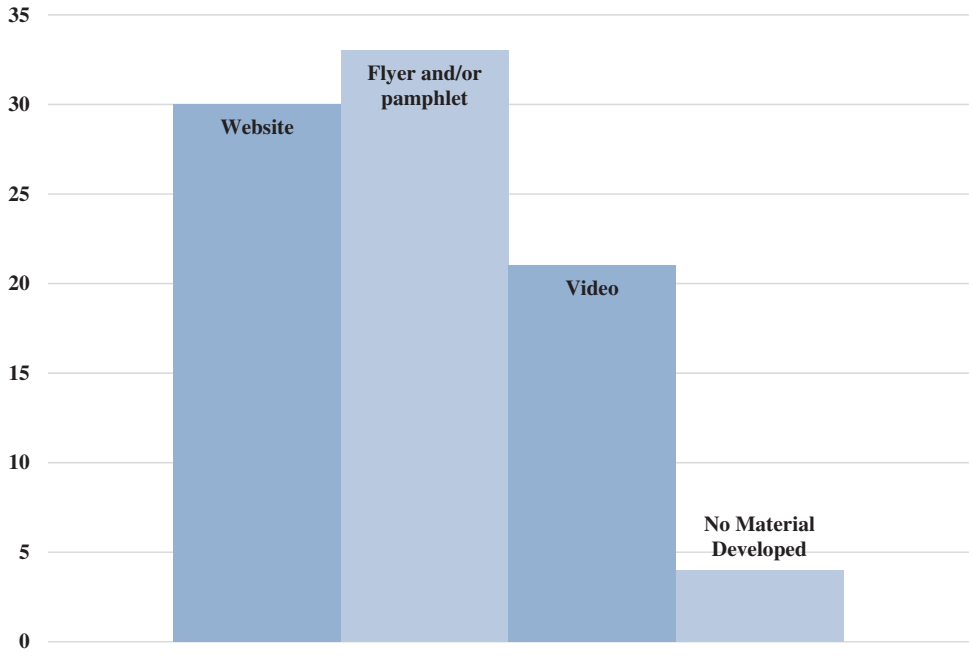


FIGURE 25 Number of state agencies developing types of public outreach material as reported by state agency.

TABLE 9
PUBLIC INFORMATION OPEN HOUSE STRATEGIES REPORTED AS USED BY STATE AGENCIES

Public Information Open House Strategy	Reporting States Agencies Using Strategy	%
Attendance from "high-ranking" agency official	19	50
Attendance from agency staff	37	97
Attendance from roundabout design team	34	89
Attendance from traffic engineers involved in the project	35	92
Attendance from transportation planners involved in the project	26	68
Charts, figures, etc... on display boards	33	87
Flyer and/or pamphlet	34	89
Presentations	36	95
Question and answer session (town hall meeting)	28	74
Scaled plan sets with vehicle models	21	55
Video	29	76
Video of roundabout simulation	31	82
Public information open houses not used	1	3

have developed their own tools, including spreadsheets implementing *HCM 2010* equations. Further, several state representatives commented that they specify different tools for the analysis of different time periods (existing versus future), or double-check results using a different tool if the capacity threshold is in question.

Safety Analysis

States were asked how their state analyzes safety performance at roundabouts. As shown in Table 12, five states (13%) do not typically analyze safety performance at roundabouts. Of the 38 responding states, 19 use either crash modification factors or crash reduction factors to analyze the safety performance at roundabouts, and 17 use the *Highway Safety Manual* predictive methodology. (States were allowed to select more than one response.) Five states have also developed state-specific procedures, and two use information published by the Insurance Institute for Highway Safety (IIHS).

ROUNDABOUT DESIGN

This section provides the results of the survey concerning the use of *NCHRP Report 672*, the use of a phased roundabout design approach, design-vehicle accommodations, and illumination at roundabouts.

TABLE 10
OPERATIONAL PERFORMANCE MODELS REPORTED AS USED BY STATE AGENCIES

Model	Reporting State Agencies Using Model	%
HCM 2010 Model	*26*	*72*
Base HCM 2010 Model	22	61
HCM 2010 Model calibrated to local conditions	12	33
HCM 2010 Model calibrated to non-local conditions	2	6
SIDRA Standard Model	*27*	*75*
SIDRA Standard Model with Environment Factor	20	56
SIDRA Standard Model without Environment Factor	13	36
UK Equations	*8*	*22*
UK Equations uncalibrated	4	11
UK Equations calibrated	4	11
Microsimulation	*22*	*61*
Other	*0*	*0*

TABLE 11
OPERATIONAL ANALYSIS SOFTWARE TOOLS REPORTED AS USED BY STATE AGENCIES

Software Tool	Reporting State Agencies Using Software Tool	%
ARCADY	3	8
HCS	19	51
RODEL	9	24
SIDRA	28	76
State Agency-developed Tool	3	8
Synchro	20	54
VISTRO	2	5
Other*	4	11

*In comments, three listed VISSIM and 1 indicated Excel Spreadsheet.

TABLE 12
SAFETY ANALYSIS PROCEDURES REPORTED AS USED BY STATE AGENCIES

Safety Analysis Procedure	Reporting State Agencies Using Safety Analysis Procedure	%
Our state does not typically estimate or predict safety at roundabouts	5	13
Highway Safety Manual predictive methodology	17	45
Crash modification factors or crash reduction factors (uncalibrated)	19	50
Crash modification factors or crash reduction factors (calibrated to local conditions)	9	24
Other Responses	7	18
Insurance Institute for Highway Safety	2	5
State agency-specific procedure	5	13

Use of *NCHRP Report 672*

States were asked the extent to which their agency uses *NCHRP Report 672* for roundabout design guidelines. As shown in Table 13, 11 states use only *NCHRP Report 672*, 10 use material from other sources to supplement it, and 13 have developed their own guidance to supplement it. Three states either do not use, or rarely use, *NCHRP Report 672*, with two using materials from other sources, and one state having developed its own guidelines. However, two of the three states that rarely use *NCHRP Report 672* indicated that this report had been a primary source in the development of their own design guidance.

Phased Roundabout Implementation

States provided information on the use of a phased roundabout implementation approach over the project life (e.g., a single-lane roundabout expanded to a multilane roundabout). As shown in Table 14, 23 of the reporting 37 states use a phased approach.

If state agencies indicated they used a phased implementation approach, they were asked if they had criteria for determining when such an approach should be used. Eleven (11) states indicated they did have criteria. Although the criteria vary, five of the 11 indicated that they will move forward with a single-lane roundabout if the roundabout is projected to operate "acceptably" for at least 10 years. Three others indicated the determination was on a case-by-case basis.

Roundabout Design Life

States also provided information on the roundabout design life used to determine the ultimate design. As shown in Table 15, 29 of the 38 responding state agencies use a fixed duration for the design life, with seven setting the design-life on a case-by-case basis, and four using a practical design policy. (States were allowed to select more than one response.) No state agencies cited specific criteria or a fixed design year. The states using a fixed duration were asked to provide the number of years (Figure 26). Several states indicated more than one design life duration, but the clear majority use 20 years for the design life.

States indicating they use a case-by-case basis or a practical design policy were asked to share how frequently they use various design life options. As shown in Figure 27, the most common design life is also 20 years. A design life of five years,

TABLE 13
STATE AGENCY USE OF *NCHRP REPORT 672* AS REPORTED BY STATE AGENCY

Use of *NCHRP Report 672* to Provide Design Guidance	Reporting Number of State Agencies
NCHRP Report 672 is the only source of design guidance.	11
Material from other sources supplements *NCHRP Report 672*	10
Our state has developed guidance to supplement *NCHRP Report 672*	13
Our state uses material from other sources, and does not use, or rarely uses, *NCHRP Report 672*	2
Our state has developed separate guidance and does not use, or rarely uses, *NCHRP Report 672*	1
Total	**37**

TABLE 14
REPORTED STATE AGENCY USE OF A PHASED IMPLEMENTATION APPROACH TO MULTILANE ROUNDABOUTS

State Agency Use of a Phased Implementation Approach to Multilane Roundabouts	Reporting Number of State Agencies
Yes	23
No	14
Total	**37**

TABLE 15
ROUNDABOUT DESIGN LIFE CRITERIA REPORTED AS USED BY STATE AGENCIES

Design-Life Criteria	Reporting State Agency Responses	%
Case-by-Case Basis	7	18
Practical Design Policy	4	11
Specific Criteria	0	0
Fixed Design Year	0	0
Fixed Duration	29	76

or more than 20 years, is not common, and a design-life of 10 years is used by only a few state agencies.

Design Vehicle Accommodation

States were asked if their agency had developed guidance on the accommodation of large vehicles (trucks, emergency

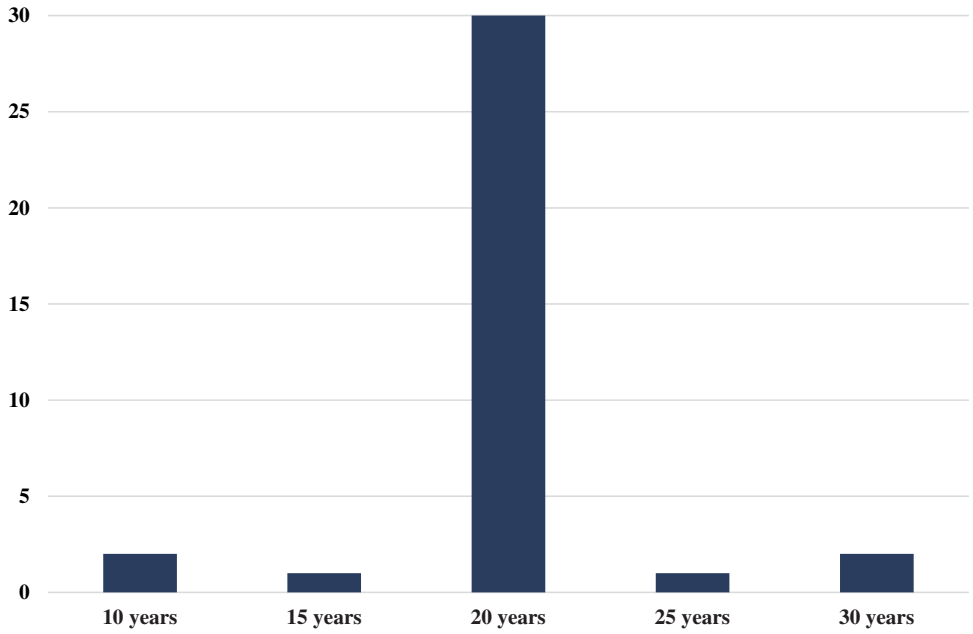


FIGURE 26 Number of reporting states indicating roundabout design life used by state agencies with a fixed design-life duration.

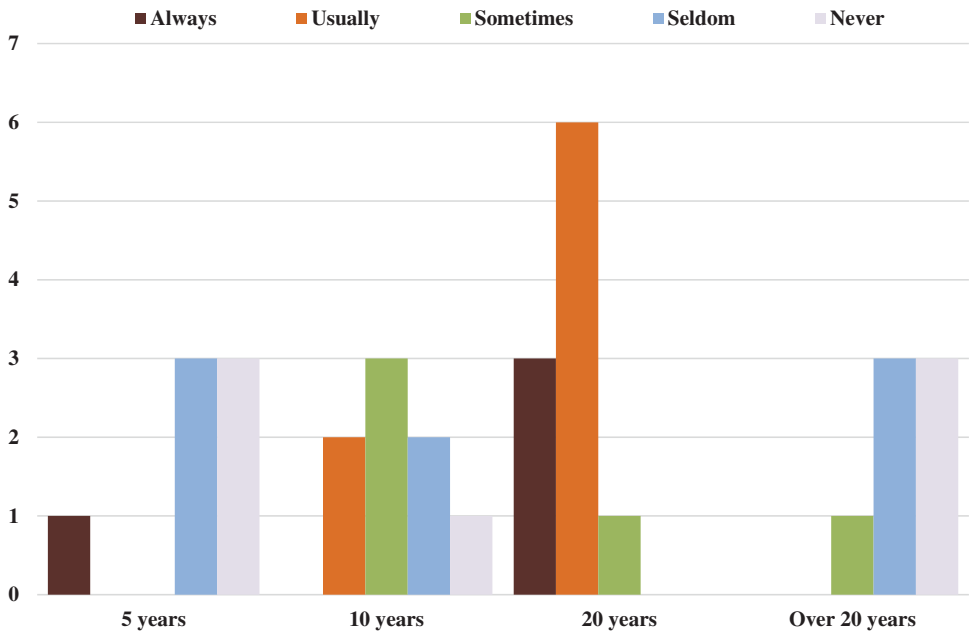


FIGURE 27 Frequency of the use of design life duration options for reporting states using case-by-case basis or a practical design policy.

TABLE 16
ILLUMINATION STANDARD/GUIDANCE REPORTED AS USED BY STATE AGENCIES

Illumination Standard/Guidance	Reporting State Agencies Using Particular Illumination Standard/Guidance	%
AASHTO Roadway Lighting Design Guide	20	54
NCHRP Report 672 (IES Design Guide for Roundabout Lighting)	20	54
State-Specific Standard	6	16
Other	8	22

vehicles, farming equipment, oversize/overweight vehicles, etc.) at roundabouts. Of the 38 states responding to the question, 19 (50%) indicated their agency had developed guidance. Several states simply guide designers to use a WB-67 design vehicle, and at least four states are currently in the process of developing guidance for the accommodation of large vehicles.

Illumination at Roundabouts

States were asked if they follow developed standards/guidance on the illumination of roundabouts, and all 38 reporting states indicated they do follow developed guidance. However, one state indicated that although it uses the *IES Design Guide*, it does not require the illumination of roundabouts. States were asked to choose between the *AASHTO Roadway Lighting Guide, IES Design Guide, NCHRP Report 672*, a state-specific standard, or other guidance. However, because *NCHRP Report 672* illumination guidance is based on the *IES Design Guide*, responses shown in Table 16 for either choice were combined.

As shown in Table 16, 20 of the 37 states that responded use the *AASHTO Roadway Lighting Guide*, and 20 use *NCHRP Report 672* (*IES Design Guide*). Six states have developed their own state-specific standard, and eight use an alternative approach, such as *Roundabouts: An Informational Guide* (1st Edition), and AASHTO's 1984 *An Informational Guide for Roadway Lighting.*

CHAPTER FOUR

CASE EXAMPLES OF ROUNDABOUT PRACTICES

Interviews were conducted with representatives of seven state DOT, who sere selected based on the following guidelines and feedback from the Topic Panel:

- Known leaders in the roundabout field
- A mix of early adopter and more recent adoption states
- A geographic mix of states
- Preference given to panel member states
- Preference given to states who have participated in similar interviews in the past to allow for a comparative review.

The selected states, highlighted in Figure 28, are California, Connecticut, Georgia, Kansas, Maryland, Minnesota, and Washington. The state DOT representatives were asked about their responses to the survey, and additional questions were asked about the following five topics:

- Roundabout selection
- Phased roundabout implementation
- Modifications to existing roundabouts
- Design vehicle accommodations
- Accelerated low-cost roundabouts.

This chapter summarizes the discussion of each of these items.

ROUNDABOUT SELECTION

As indicated in the survey, safety is still the number one factor in the selection of roundabouts. The interviews suggest that a policy, directive, or guide suggesting or mandating that a roundabout be considered as an option also drives the selection of roundabouts, as do political reasons or changes in policies. Before the adoption of the ICE policy in California (*45*), the performance of roundabouts was not being evaluated because of the increased degree of difficulty involved with assessing the feasibility of roundabouts compared with other intersections forms. After the implementation of the ICE policy, the number of roundabouts considered "increased overnight."

However, despite policies that indicate a roundabout should be considered, some of the state officials interviewed still struggle to get roundabouts included in the evaluation outside of certain situations. In Connecticut, a roundabout might only be considered if the municipality requests one, a consultant that has experience with roundabouts proposes one as an alternative, or a DOT employee at headquarters or a regional office champions the roundabout alternative. In Georgia, a roundabout can be dismissed from consideration without a preliminary scaled aerial sketch to analyze a roundabout's potential impacts.

The interviews also highlighted that in addition to differences among policies concerning the selection of roundabouts, there are also differences in the enforcement of policies. Maryland, for example, strongly enforces its policy requiring the evaluation of a roundabout as part of the development review process; because of this policy, developers and the transportation engineers working for them are now proposing roundabouts knowing that the SHA will require them to do so.

In Georgia. more than half of the roundabouts in the current program were selected and funded as part of GDOT's safety program. Five of the seven states profiled indicated that cities and towns now request roundabouts, while the other two have an ICE policy in place that mandates a roundabout be considered as an alternative. Although many of Maryland's original roundabouts were selected because of existing safety problems at intersections, roundabouts have become the first choice for many of Maryland's district engineers, regardless of the safety record at that intersection.

MODIFICATIONS TO EXISTING ROUNDABOUTS

Several interviewees discussed modifications to existing roundabouts resulting from identified safety or operational problems. Most of the modifications to date involved reducing the number of lanes because of excess capacity at the roundabout. In many cases, this involved converting multilane facilities that were overbuilt for future traffic volumes to single-lane roundabouts. An example is the US-50/Connector Road roundabout in Emporia, Kansas, which was opened as a multilane roundabout (Figure 29) with three lanes on the east and west approaches; and was later converted to a single-lane roundabout (Figure 30) through striping and an expanded truck apron.

At two locations, WSDOT reduced the capacity of multilane roundabouts to minimize minor crash patterns. By reducing the number of lanes on the approach to the roundabout, it was able to reduce the number of points where crashes can occur.

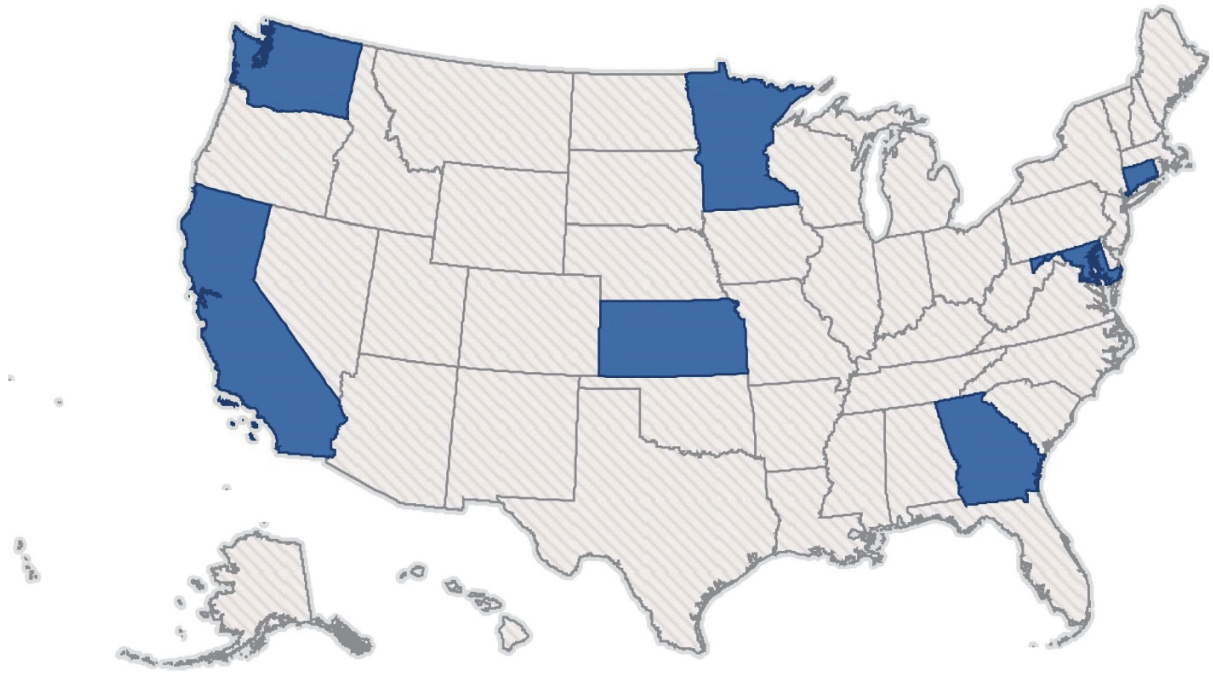


FIGURE 28 States interviewed.

Minnesota DOT (MnDOT) has modified several roundabouts from their original design. The 20-year traffic forecast was used for the design, and a multilane roundabout was installed. One location had performance issues immediately, and it was found that traffic volumes were low enough that a single lane would be sufficient. The roundabout was converted to a single-lane roundabout using pavement markings and signage, and is operating acceptably. Because of this experience, MnDOT is now considering installing single-lane roundabouts if the operational analysis shows that the roundabout is at the margin of requiring multiple lanes.

State DOTs have also updated other types of circular intersection to improve safety and operations. Connecticut DOT (ConnDOT) and Caltrans have modified rotaries using roundabout design techniques. FHWA and the Roadway Safety Foundation awarded ConnDOT a national roadway safety award for the rotary conversion project.

PHASED ROUNDABOUT IMPLEMENTATION

As mentioned previously, at least five of the seven states interviewed have modified roundabouts by reducing capacity. Because of this experience, all seven DOTs are now actively attempting to size their roundabouts for immediate and near-future vehicle demand. Some state DOTS are using phased roundabout implementation to address the issue of overbuilding them. Kansas, for instance, is now actively promoting the use of a phased roundabout implementation approach through its recently published second edition of the Kansas *Roundabout Guide.*

FIGURE 29 As-constructed US-50/Connector Road Roundabout in Emporia, Kansas. *Source*: Google Earth Aerial (*46*).

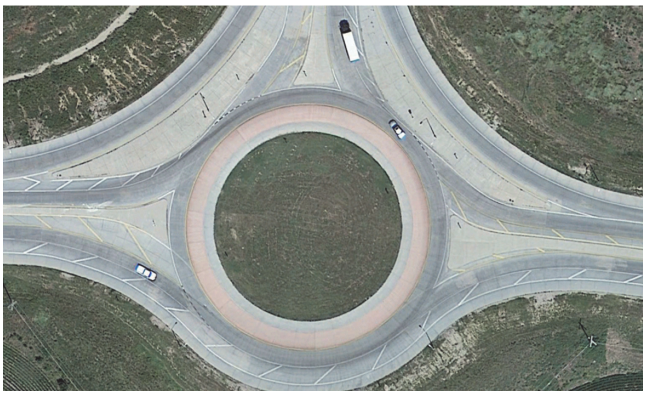


FIGURE 30 Modified US-50/Connector Road roundabout in Emporia, Kansas. *Source*: Google Earth Aerial (*47*).

FIGURE 31 As-constructed I-495/Ritchie-Marlboro Road ramp terminal roundabouts. *Source*: Google Earth Aerial (*48*).

As mentioned in the questionnaire summary, most states use a 20-year design life for their roundabout analyses, and many states, including Georgia and Maryland, will open the roundabout as a single-lane roundabout if that configuration is expected to be sufficient for approximately 10 years. Another factor, as the ConnDOT respondent pointed out, is the uncertainty with current forecasting methods. The Maryland SHA pointed out that the Towson Circle roundabout in Towson, Maryland, was opened as a multilane roundabout with two entry, exiting, and circulatory lanes on all approaches, and was designed to be expanded to three lanes in the future (Figure 31). However, the Towson Circle was modified in 2008 to reduce the number of lanes, and Maryland SHA indicated that it will likely never be expanded.

Although multiple states that were interviewed said they have built a roundabout with a phased implementation strategy, only the Maryland SHA operates a roundabout that had been expanded. As shown in Figure 32, the I-495/Ritchie-Marlboro Road interchange ramp terminal intersections were expanded from two to three lanes in advance of development in the vicinity.

DESIGN VEHICLE ACCOMMODATION

The selection of a design vehicle is often based on roadway classification, with most states using WB-62, WB-65, or WB-67s as the default design vehicles for state routes at all intersections, not only roundabouts. The default design vehicle for a state route is typically the state route movements at a roundabout, such as through movements on the state route at a roundabout intersection of a state road and local road. The design vehicle for other movements at a roundabout is typically based on local agency guidelines and adjacent land uses. In an effort to limit the size of roundabouts and provide speed control, WSDOT determines the specific movements larger vehicles are expected to make at an intersection, and designs its roundabouts to accommodate large vehicles on those movements.

FIGURE 32 Modified I-495/Ritchie-Marlboro Road ramp terminal roundabouts. *Source*: Google Earth Aerial (*49*).

Oversize/overweight vehicles, including vehicles such as low-boys with low vertical clearance, are only used as design vehicles on certain state highways with special freight needs. Most of the states interviewed use four-inch truck aprons adjacent to the central island, but some of the state agencies are considering lower height truck aprons to accommodate vehicles with low vertical clearance. WSDOT recently modified its truck apron height from three inches to two inches in certain applications.

GDOT tracks the routes of oversize/overweight vehicles statewide, and is able to determine the types of vehicles likely to traverse the proposed roundabout, and the movements the large vehicles are expected to make at the intersection. Alternatively, GDOT will consider parallel routes for infrequent movements of large vehicles. KDOT only tracks oversize/overweight vehicles, so it is unable to determine specific movements at intersections that need to accommodate an oversize/overweight vehicle movement. Consequently, KDOT designs the proposed roundabout to accommodate all oversize/overweight vehicle movements.

ACCELERATED, LOW-COST ROUNDABOUTS

GDOT's District 1 used state forces to install a mini-roundabout at the intersection of SR-11/SR-124/Galilee Church Road in Jackson County, Georgia, over several weekends in April and May of 2013. Figures 33–36 show the intersection before, during, and after construction.

Flexible curbing was used around the circumference of the central island, which was backfilled with asphalt. Since its original construction, the district has installed a concrete curb. The project included widening on three of the four corners of the intersection to accommodate the 90-foot inscribed circle diameter. Construction costs were $63,000, including full repaving and striping.

FIGURE 34 Intersection of SR-11/SR-124/Galilee Church Road in Jackson County, Georgia, during first weekend of construction of the accelerated low-cost roundabout. *Source*: Zehngraff (*50*).

Two additional projects were completed under the same quick response contract, which is a contracting mechanism with a $200,000 cap. In one of the locations, the GDOT District 3 maintenance staff worked with a general contractor at the intersection of Cedar Rock Road and SR-81 in Hotchkins, Georgia, to rebuild the intersection as a roundabout. The contractor constructed the central island and grading out of a rigid plastic modular curbing system and then District 3 maintenance staff laid the asphalt overlay on all approaches. The total roundabout construction cost was $300,000. The second location was constructed of a rigid plastic modular system.

FIGURE 33 Intersection of SR-11/SR-124/Galilee Church Road in Jackson County, Georgia, prior to construction. *Source*: Zehngraff (*50*).

FIGURE 35 Intersection of SR-11/SR-124/Galilee Church Road in Jackson County, Georgia, during second weekend of construction of the accelerated low-cost roundabout. *Source*: Zehngraff (*50*).

FIGURE 36 Accelerated low-cost roundabout installation at the intersection of SR-11/SR-124/Galilee Church Road in Jackson County, Georgia. *Source*: Zehngraff (*50*).

Both of these low-cost implementations were delivered in less time that a typical roundabout project, which entails a rigorous review process. These projects also yielded a high rate of return on investment. The SR-11/SR-124/Galilee Church Road roundabout in particular was found to have reduced crashes at the intersection and shortened a quarter-mile stopped queue to an eight-to-10-car rolling queue.

Georgia is not alone in this practice. WSDOT has installed accelerated, low-cost roundabouts at four locations. These compact roundabouts were interim fixes, all constructed in a weekend. Although there is no policy in place for this type of installation, it has been embraced as a technique for rapid deployment of an intersection retrofit. Candidate locations for this type of installation are at the nodes of an interchange where there are recurring backups onto the mainline. These projects typically include pavement markings and signs, with a budget of $200,000 to $300,000.

In 2007, Maryland SHA installed a 75-foot diameter mini-roundabout at an interchange off-ramp at the intersection of US 50 and Thompson Creek Road in Stevensville, Maryland (Figure 37). The roundabout was installed using only thermoplastic pavement markings. No curbing or pavement was used for the installation. The only additional materials used were vertical flexible posts to delineate the center island. The cost of the installation was around $50,000, and the roundabout has been in place since 2007.

EFFECTIVE PRACTICES

This section provides a summary of effective practices and lessons learned identified from the DOT interviews. Because each state is at a different stage in their experience with roundabouts, the primary topics and key takeaways are unique.

FIGURE 37 Accelerated low-cost roundabout installation at the intersection of US-50/Thompson Creek in Stevensville, Maryland. *Source*: Jenior (*51*).

California

Roundabouts have been being built in California since the early 1990s. Over the past decade roundabouts were primarily considered through the Caltrans safety program. With the advent of the ICE policy in 2013, roundabouts have emerged as a preferred intersection type, consistently having the optimum outcome in comparisons of different intersection types. Hence, the ICE process has had a dramatic effect on the consideration of roundabouts in California.

Connecticut

ConnDOT is both building roundabouts and modifying rotaries, which has led to improved safety performance. The award-winning Killingworth Rotary Modification project reduced the frequency and severity of crashes by incorporating elements of roundabout design. Although roundabouts are not the preferred type of intersection control, Connecticut is looking to incorporate stronger language in the upcoming revision to the roadway design manual. ConnDOT is looking at cost-effective ways to deliver all types of transportation projects, including scaling back the design horizon to a 10-year design period.

Georgia

GDOT built its first single-lane roundabout in Georgia in 1999, but it was not until 2008 that multilane roundabouts were allowed to be built in the state. GDOT has become very judicious about the number of lanes they use in their roundabouts. When evaluating a multilane roundabout, GDOT attempts to use a phased implementation approach. If a single-lane roundabout can operate effectively for seven to 10 years, GDOT will open it as a single-lane roundabout designed for future expansion. GDOT has developed a checklist for roundabout designs, and it has developed its own roundabout analysis tool based on the HCM 2010 model. For future-year analyses, GDOT uses calibration factors from California and Bend, Oregon. GDOT has built several low-cost roundabouts that were installed in a matter of days. GDOT sees the benefit of reduced crashes and improved operations through roundabout implementation, which may not always require a "textbook" approach.

Kansas

KDOT has been viewed as a leader in the implementation of roundabouts in the United States. The first edition of the Kansas Roundabout Guide was adopted by several other states, and even a Canadian province, British Columbia. In the second edition of the guide, released in 2014, KDOT developed guidance to support the oversize/overweight vehicles that are becoming more common in Kansas. Roundabouts in Kansas, especially in the more rural areas, are responses to identified safety concerns. Many have been constructed at the local level, especially in Lawrence and suburbs of Kansas City. In the past, KDOT has provided peer review support to local jurisdictions as well, which has helped keep the quality of roundabout designs high, even when KDOT is not officially involved.

Maryland

Maryland (SHA) established the nation's first state roundabout program in the early 1990s. In the early years, SHA concentrated on identifying intersections with a crash history that could be mitigated by roundabouts, and required all SHA districts to identify intersections. Later, SHA developed a policy requiring the evaluation of roundabouts, and because of Maryland's positive experience with roundabouts and a strict enforcement of the policy, roundabouts have become the default intersection choice in the state. Many of SHA's early multilane roundabouts were later scaled back because of safety or operational issues, and because of this experience, SHA has made a strong push towards a phased implementation approach at roundabouts. Similar, because of its experience, SHA is spending much more on roundabout projects than in the early 1990s by making sure that all roundabouts have curbs, gutters, and illumination.

Minnesota

Since 2009, MnDOT has been using an ICE process for selecting intersection types. However, it was not until a few years ago that MnDOT started formally evaluating roundabouts as part of the ICE process, which is the primary mechanism for roundabouts selection. MnDOT has found that excess capacity at multilane roundabouts has resulted in an increased number of property damage only crashes. Because of this experience, when the anticipated future traffic volumes dictate the need for a multilane roundabout, MnDOT evaluates whether the roundabout can be opened as a single-lane roundabout with capacity added when required. Recently, two multilane roundabouts were reduced to single-lane roundabouts, and the number of crashes was reduced accordingly.

Washington

WSDOT has constructed more than 100 roundabouts on the state highway system and has been building roundabouts for more than 15 years. WSDOT has developed state-specific roundabout design guidance. Working with the trucking industry, WSDOT developed design techniques aimed at accommodating large vehicles while still maintaining compact roundabout designs, including specifying curbing details and allowing lane straddling. The combination of these design techniques helps both to accommodate larger vehicles and keep vehicle speeds low.

CHAPTER FIVE

CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH

This synthesis provides state-of-the-practice information about roundabout practices within state departments of transportation (DOTs) across the United States. Information about current roundabout practices was taken from literature, from 40 state responses to a questionnaire, and interviews with state DOT personnel from seven states.

The growth in roundabouts over the past 25 years, both in total numbers and their broad application and use across the country, is notable. The 1998 *Synthesis of Highway Practice 264: Modern Roundabout Practice in the United States* provides a useful comparison between roundabout practices prior to the publication of the first FHWA roundabout guide in 2000 and today. In 1997, only nine state agencies had a roundabout in operation, and only a third of the states without a roundabout on their state highway system were considering the construction of roundabouts. Today, 38 of the 40 reporting states have a roundabout in operation. Of the two states reporting that their agency has no roundabout on the state highway system, one reported that a roundabout has been planned or designed but has not yet been built, and the other is considering the construction of roundabouts.

According to the state questionnaire responses and interviews, current roundabout practices can be summarized as follows:

- Improved safety performance is the primary reason cited for the selection of roundabouts compared with other intersection options. Shorter vehicular delays and higher capacity were the next most frequent responses. The reasons least frequently reported for selection of roundabouts were lower initial capital costs and requests from an election official.
- However, despite the documented safety performance of roundabouts compared with other intersection control options, several interviewed states cited continuing challenges with evaluating roundabouts on an equal footing with other options. Several states have developed policies requiring the evaluation of roundabouts to varying degrees of success depending on how well the policy is enforced, In other states, the use of Intersection Control Evaluation policies has had the effect of increasing the number of roundabouts evaluated.
- State agencies provided planning-level costs (screening or feasibility level estimate) of mini-, single-lane, and multilane roundabouts averaging $249,000, $1.30 million, and $2.05 million, respectively.
- The majority of reporting states have public education materials to support roundabout projects. Most have created a roundabout website and a flyer and/or pamphlet. About half have developed videos. Only a few respondents indicated they had not developed any public outreach material.
- To analyze roundabout performance, about three quarters of the reporting states use some form of the Highway Capacity Manual 2010 model and SIDRA's Standard Model, and about a one-quarter of the reporting states use some form of the United Kingdom equations.
- Most of the reporting states analyze safety performance at roundabouts. About half of the reporting states use crash modification factors, crash reduction factors, and/or the *Highway Safety Manual* predictive methodology to measure safety performance. A handful of states have also developed state-specific procedures, and a couple of states use information published by the Insurance Institute for Highway Safety (IIHS).
- *NCHRP Report 672: Roundabouts: An Informational Guide*, 2nd edition, is used by most of the reporting state agencies for design guidance. About one-quarter of the states only use *NCHRP Report 672*, another one-quarter uses material from other sources to supplement their use of *NCHRP Report 672*, and a third quarter have developed their own guidance to supplement this report. Only a few states either do not use, or rarely use, *NCHRP Report 672*; two use materials from other sources, and one has developed their own guidelines.
- Most states use a design life of 20 years when developing the ultimate roundabout design. However, more than half of the states use a phased implementation approach over the project life, indicating they prefer to open a roundabout in a single-lane or other smaller configuration, with the ability to expand the roundabout when traffic volume increases. About a quarter of the state reported developing criteria for the use of a phased implementation approach, and a handful of states indicated they would move forward with a single-lane roundabout if it were projected to operate "acceptably" for at least 10 years.
- Many states, especially the early-adopter states (defined as having built a roundabout before the year 2000), have experienced the need to modify existing roundabouts owing to identified safety or operational problems. Most

of the modifications involved reducing the number of lanes owing to excess capacity at multilane facilities that were overbuilt. Largely because of this experience, all seven interview participants indicated they use a phased approach to roundabout implementation and are actively attempting to size their initial constructed configuration for the vehicle demand that will be present at the intersection in the immediate and near future.
- Half of the reporting states indicated their agency had developed design-vehicle guidance. Several states supply guidance to the use of a large tractor-trailer truck (WB-67) design vehicle, and a few others are currently in the process of developing guidance for the accommodation of large vehicles. The interview participants indicated they are using different techniques to accommodate oversize/overweight vehicles at roundabouts, depending on how oversize/overweight vehicles are tracked across their state highway system.
- All reporting states follow developed illumination guidance, with only one state indicating it does not require the illumination of roundabouts. More than half of the reporting states use the AASHTO *Roadway Lighting Guide*, about one-quarter use the IES *Design Guide*, and about one-third use *NCHRP Report 672.* A handful of states have developed their own state-specific standard.
- Several states have installed accelerated, low-cost roundabouts, which involves roundabouts implemented at a substantially reduced cost or time. For instance, the Georgia DOT installed a mini-roundabout in a rural location over several weekends. The Washington State DOT and Maryland State Highway Administration also have experience with accelerated, low-cost roundabouts.

After reviewing the responses to the questionnaire and interviews, some key questions still remain: What are effective strategies for ensuring roundabouts and other intersection forms are consistently evaluated using state of the practice methods and measures? What strategies can be used to reduce the total cost of a roundabout installation? Is it better to construct roundabouts without lighting than to not construct a roundabout at all?

The following key topics emerged from this synthesis as areas recommended for future research:

- There is a general need continually to advance the planning, evaluation, and design guidance available related to roundabouts. *NCHRP Report 672*, used by almost all of the reporting states, provided the most up-to-date guidance available when it was published in 2010. A significant amount of new material, including this synthesis, has been developed in the interim, and several states have developed their own design guidance to supplement and/or advance the information. As documented in the responses to survey questions and state interviews, there is also a need for continuing information about definitions and safety issues related to roundabouts. The production of a third edition of *Roundabouts: An Informational Guide* would help to disseminate this updated information to practitioners.
- Several state agencies expressed a desire to identify and disseminate strategies for limiting the installation costs of roundabouts. Specific items identified as contributing to the rising costs if roundabout implementation include the maintenance of traffic during construction, the use of curb-and-gutter sections, and illumination. Although research has been conducted documenting the safety benefits of roundabouts, limited research has been conducted on whether individual items, such as illumination, can be excluded from the roundabout without sacrificing the overall safety benefits. In addition, identifying particular applications, such as interchange ramp terminals where roundabouts may have additional cost benefits, would be beneficial for states looking to maximize cost-effectiveness.
- States are searching for ways to ensure roundabouts and other intersection forms are evaluated using state-of-the-practice methods and measures. A comparison of rate of implementation among states with different roundabout policies and particularly Intersection Control Evaluation policies might shed more light on their effectiveness. Furthermore, research on the enforcement of policies and the development and use of roundabout programs at the state level may identify effective strategies for ensuring the consideration of reasonable intersection control options.
- Almost all reporting states have developed public outreach materials related to roundabouts. However, additional research on their effectiveness could be helpful in identifying successful strategies and prioritizing resources towards them, and may help alleviate push-back against roundabouts.
- The majority of states are now using a phased implementation approach in the design of roundabouts. However, because of the small number of roundabouts expanded to date, before/after data related to the planned expansion of roundabouts are limited. If the number of roundabouts that are expanded to their ultimate footprint increases over the next few years, additional research on the most effective practices for planning and funding expansion, along with managing traffic during reconstruction, could be helpful to state agencies.

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APPENDIX A

Summary of Statewide Roundabout Policies

State	Policy Type	Policy Text	Policy Source
Alabama	None	N/A	N/A
Alaska	Preferred	"Roundabout First" policy. Requires designers to provide a written justification of any decision to install a traffic signal instead of a single lane roundabout.	Alaska DOT&PF roundabout website (*52*)
Arizona	Allow	After ADOT assesses the input from the first two items above, ADOT staff will then determine whether or not to "consider" roundabouts.	ADOT roundabout website (*53*)
Arkansas	Allow	Implement… roundabouts, as appropriate.	Arkansas' Strategic Highway Safety Plan (*54*)
California	Evaluate	Proposals to employ full control at state highway intersections (i.e. to control all approaching traffic via us of signal, stop or yield control) must consider all three intersection control strategies and the supporting design configurations during the ICE screening process.	Traffic Operations Policy Directive (TOPD) 13-02 (*45*)
Colorado	Encourage	Inferred	N/A
Connecticut	Encourage	Those locations which meet or nearly meet [signal] warrants, should be given consideration for roundabout installation. Intersections that are, or proposed to be, all-way stop controlled may also be good candidate locations for a roundabout	Use of Roundabouts on State Highways Memorandum (*55*)
Delaware	Encourage	The potential benefits of reductions in injuries and costs associated with crashes are sufficient alone to recommend modern roundabouts as a first option when safety, capacity, or traffic calming are chief reasons for intersection projects	Delaware Department of Transportation Guidelines on Roundabouts (*56*)
District of Columbia	Allow	Inferred	N/A
Florida	Evaluate	Roundabouts shall be evaluated on new construction, reconstruction and safety improvement projects, as well as anytime there are proposed changes in intersection control that will be more restrictive than the existing conditions.	Florida Roundabout Guide (*57*)
Georgia	Evaluate	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: (1) Any intersection in a project that is being designed as new or is being reconstructed. (2) All existing intersections that have been identified as needing major safety or operational improvements. (3) All signal requests at intersections (provide justification in the Traffic Engineering Study if a roundabout is not selected).	Modern Roundabouts in Georgia (*58*)
Hawaii	Encourage	[Roundabouts] should be considered as alternatives to stop lights and stop signs	News Article (*59*)
Idaho	None	None	N/A
Illinois	Encourage	Roundabouts [should] be considered as an alternative intersection during all intersection improvements.	Illinois Center for Transportation: Roundabout Evaluation and Design: A Site Selection Procedure (*60*)

State	Policy Type	Policy Text	Policy Source
Indiana	Encourage	A roundabout should be considered as one potential intersection option within an INDOT-sponsored or -funded planning study or project since it offers improved safety, cost savings, and enhanced traffic operations. This includes a proposed freeway interchange where an at-grade intersection currently exists or will be created at the ramp terminals. A comparison of roundabout practicality or feasibility versus other intersection types should be conducted, considering safety, traffic operations, capacity, right-of-way impacts, and cost. Other factors as described below can also be included in the evaluation if desired and deemed appropriate. In conducting such comparisons, a roundabout is not always the optimal solution, but it can often offer significant benefits.	The Indiana Design Manual (*61*)
Iowa	Encourage	The Iowa Department of Transportation and other communities in Iowa have started using roundabouts in certain situations to enhance safety and reduce delays encountered by the motoring public.	Iowa Comprehensive Highway Safety Plan (CHSP) (*62*)
Kansas	Encourage	While KDOT does not have a formal policy at this time dictating the use of roundabouts, KDOT prefers that roundabouts be considered as an intersection alternative for potential operations and safety improvements.	Kansas Roundabout Guide (*63*)
Kentucky	Allow	A modern roundabout is an alternative form of intersection control to traffic signals and multi-way stop control intersections. Therefore, roundabouts may be considered only when these intersection control types are warranted.	Highway Design: INTERSECTION—At Grade Intersections: Modern Roundabouts (*64*)
Louisiana	Allow	Roundabout shall be justified by a benefit cost safety analysis or a capacity analysis comparison. There must be sound engineering reason to justify the installation of a roundabout.	EDSM VI.1.1.5—Roundabout Safety and Approval (*65*)
Maine	Allow	MaineDOT will generally allow implementation of a roundabout provided that over a 20-year design life, basic safety standards are met and the roundabout performs equal to or better than the no build alternative. In the event that mobility is reduced compared to the no build alternative, MaineDOT will consider whether reduced mobility is part of the Purpose and Need along with posted speed limits, Highway Corridor Priorities and Customer Service Levels.	Maine DOT Roundabout Analysis Requirements (*66*)
Maryland	Evaluate	SHA has adopted a policy that roundabouts will be considered at all intersections where improvements are being considered.	Maryland Roundabout Program: Early Years and Program Growth (*67*)
Massachusetts	Encourage	Roundabouts can be appropriate design alternative to both stop-controlled and signal-controlled intersections. … At higher combinations of major street and minor street volume, traffic signals become the common traffic control measure. Roundabouts should also be considered in these situations.	Massachusetts Highway Design Guide (*68*)
Michigan	Encourage	Roundabouts should be considered as one potential intersection option within MDOT-sponsored or funded planning studies/design projects since they offer improved safety, cost savings, and enhanced traffic operations in many situations.	MDOT Roundabout Guidance Document (*69*)

State	Policy Type	Policy Text	Policy Source
Minnesota	Evaluate	In general terms, any intersection—whether in an urban or rural environment—that meets the criteria for additional traffic control beyond a thru stop condition, also qualifies for evaluation as a modern roundabout. Therefore, in any planning process for an intersection improvement where a traffic signal or a 4-way stop is under consideration, a modern roundabout should likewise receive serious consideration. Additionally, roundabouts should always be considered as an improvement strategy for existing 4-way stop or signal-controlled intersections with safety or operational problems.	MnDOT Road Design Manual: Chapter 12: Design Guidelines for Modern Roundabouts (*70*)
Mississippi	None	N/A	N/A
Missouri	Allow	The process of selecting a roundabout as the preferred form of traffic control for a given intersection has three stages. If a roundabout is not "preferred" at any one of these stages, it will cease to be considered as a viable form of traffic control at the given location.	MoDOT Engineering Policy Guide (*71*)
Montana	Encourage	Roundabouts are installed at selected state roadway intersections to improve safety and mobility.	MDT Roundabouts Website (*72*)
Nebraska	Allow	The Traffic Engineering Division conducts an engineering study to evaluate the operation of an intersection and to determine the appropriate traffic control to be provided.	Nebraska Department of Roads: Roundabouts (*73*)
Nevada	Encourage	In a continual effort to provide the safest roadways, the Nevada Department of Transportation installs roundabouts at selected State roadway intersections to improve safety and mobility.	Nevada DOT Roundabout Website (*74*)
New Hampshire	Evaluate	Roundabouts can be placed at an intersection under any type of operational control. Due to the improved safety, operation and capacity benefits of roundabouts it shall be standard procedure at the NH DOT to evaluate any intersection considering signal control to see if a roundabout would be beneficial.	NH DOT Supplemental Design Criteria (*75*)
New Jersey	Allow	A roundabout is a circular, raised traffic island placed within the intersection of two or more streets. It operates on the "yield-on-entry" principle. Drivers circumnavigate the island in a counter-clockwise direction. Roundabouts limit speeds by horizontally deflecting vehicles as they pass through an intersection. They reduce crashes by separating movements and reducing speeds.	NJDOT Roadway Design Manual, Section 15 Traffic Calming (*76*)
New Mexico	Allow	Inferred	New Mexico Department of Transportation—Driving in Roundabouts (*77*)
New York	Preferred	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 benefits and other operational benefits.	*Highway Design Manual* (*78*)
North Carolina	Encourage	The choice of using a roundabout is made on a case-by-case basis. NCDOT evaluates traffic volumes and crashes at each candidate intersection individually to determine if a roundabout would be the most effective solution.	Traffic Engineering: Policies, Practices and Legal Authority Resources (*79*)
North Dakota	None	N/A	N/A

State	Policy Type	Policy Text	Policy Source
Ohio	Encourage	Roundabouts can be placed at an intersection under any type of operational control. Due to improved safety, operation and capacity benefits of roundabouts, a roundabout may be evaluated at any intersection considering signal control to see if a roundabout would be beneficial.	Design Manual (*80*)
Oklahoma	None	N/A	N/A
Oregon	Encourage	Asks everyone to give serious consideration to intersection control alternatives beyond merely traffic signals.	Intersection Control Using Roundabouts (*81*)
Pennsylvania	Encourage	When planning for intersection improvements, a variety of improvement alternatives should be evaluated, in addition to roundabouts, to determine whether a roundabout is the most appropriate alternative.	Pennsylvania Guide to Roundabouts (*82*)
Rhode Island	Preferred	Using modern roundabouts in place of traditional intersections is a safer solution we're looking to employ wherever we can.	Roundabouts for Rhode Island (*83*)
South Carolina	Encourage	Use of roundabouts is recommended at locations with major safety or operational issues where the higher costs for the construction can be justified by the crash reduction or operational improvements.	Charting a Course to 2040; Multimodal Transportation Plan; Safety and Security (*84*)
South Dakota	None	The South Dakota Strategic Highway Safety Plan (pp. 29–31) provides information on intersection crashes and proposals for several types of improvements and preventative measures to reduce crashes, injuries and fatalities - including roundabouts.	South Dakota DOT Roundabouts website (*85*)
Tennessee	Allow	Inferred	Instructional Bulletin No. 10-07 (*86*)
Texas	Allow	Roundabouts can be appropriately implemented in Texas	Texas Roundabout Guidelines Final Report (*87*)
Utah	Encourage	Inferred	Developing Guidelines for Roundabouts (*88*)
Vermont	Preferred	The general assembly finds that the installation of roundabouts at dangerous intersections in the state has been cost-efficient, and has enhanced the safe operation of vehicles at these locations. The agency of transportation is directed to carefully examine and pursue the opportunities for construction of roundabouts at intersections determined to pose safety hazards for motorists.	Vermont Legislature (*89*)
Virginia	Preferred	VDOT recognizes that Roundabouts are frequently able to address the above safety and operational objectives better than other types of intersections in both urban and rural environments and on high-speed and low-speed highways. Therefore, it is VDOT policy that Roundabouts be considered when a project includes reconstructing or constructing new intersection(s), signalized or unsignalized. The Engineer shall provide an analysis of each intersection to determine if a Roundabout is a feasible alternative based on site constraints, including right of way, environmental factors and other design constraints. The advantages and disadvantages of constructing a Roundabout shall be documented for each intersection. 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.	Road Design Manual (*90*)

State	Policy Type	Policy Text	Policy Source
Washington	Evaluate	If warrants are met, evaluate multi-way stop, roundabout, and signal. If warrants are not met, evaluate yield, two-way stop, multi-way stop, and roundabout.	Design Manual (*91*)
West Virginia	None	N/A	N/A
Wisconsin	Evaluate	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. Where there is an existing four-way stop or signal and there are operational problems with the current control, then the roundabout shall be considered as a viable alternative. As stated above the roundabout may be a viable alternative for a two-way stop control in certain circumstances. In either case, roundabouts are a potential intersection control strategy until such time that the evaluation indicates that the roundabout alternative is not appropriate.	Roundabout Guide (*92*)
Wyoming	None	N/A	N/A

APPENDIX B

State Agency Questionnaire

NCHRP NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP Synthesis 46-02: Roundabout Design, Operations and Safety Practices - State Agency Questionnaire

Instructions

Dear AASHTO Subcommittee on Traffic Engineering Member:

The Transportation Research Board (TRB) is preparing a synthesis on Roundabout Design, Operations and Safety Practices - Synthesis Topic 46-02. This is being done for NCHRP, under the sponsorship of the American Association of State Highway and Transportation Officials, in cooperation with the Federal Highway Administration.

This questionnaire is being sent to the voting members of the AASHTO Subcommittee on Traffic Engineering. Your cooperation in completing the questionnaire will ensure the success of this effort. **If you are not the appropriate person at your agency to complete this questionnaire, please forward it to the correct person.**

Please complete and submit this survey by February 9, 2015. We estimate that it should take approximately 15 minutes to complete. If you have any questions, please contact our principal investigator, Alek Pochowski, at apochowski@kittelson.com or (202) 642-2916. Any supporting materials can be sent directly to Alek Pochowski by email.

QUESTIONNAIRE INSTRUCTIONS

1. To view and print the entire questionnaire, Click on the following link and print using "control p". NCHRP Synthesis Topic 46-02 Questionnaire
2. To save your partial answers and complete the questionnaire later, click on the "Save and Continue Later" link in the upper center of your screen. A link to the incomplete questionnaire will be emailed to you from *SurveyGizmo.* To return to the questionnaire later, open the email from *SurveyGizmo* and click on the link. We suggest using the “Save and Continue Later” feature if there will be more than 15 minutes of inactivity while the survey is opened, as some firewalls may terminate due to inactivity.
3. To pass a partially completed questionnaire to a colleague, click on the on the "Save and Continue Later" link in the upper center of your screen. A link to the incomplete questionnaire will be emailed to you from *SurveyGizmo.*" Open the email from *SurveyGizmo* and forward it to a colleague.
4. To view and print your answers before submitting the survey, click forward to the last question, and print using “control p.”
5. To submit the survey, click on "Submit" on the last page.

Thank you very much for your time and expertise.

Please enter the date (MM/DD/YYYY).

Calendar

Contact Information

Please provide your contact information so we can contact you if we have questions or would like clarification about any of your responses. If more than one person helped with the questionnaire, please provide the information for the best person to contact with questions.

First Name *

Last Name *

Title *

State Agency *

Street Address

Apt/Suite/Office

City

State

Zip Code

Alabama
Alaska
Arizona
Arkansas
California
Colorado
Connecticut
Delaware
District of Columbia
Florida
Georgia
Hawaii
Idaho
Illinois
Indiana
Iowa
Kansas
Kentucky
Louisiana
Maine
Maryland
Massachusetts
Michigan

State

Minnesota
Mississippi
Missouri
Montana
Nebraska
Nevada
New Hampshire
New Jersey
New Mexico
New York
North Carolina
North Dakota
Ohio
Oklahoma
Oregon
Pennsylvania
Rhode Island
South Carolina
South Dakota
Tennessee
Texas
Utah
Vermont
Virginia
Washington
West Virginia
Wisconsin
Wyoming

Email Address *

Phone Number *

Roundabout Definition

The exhibit below provides an example of what is considered a roundabout for the purposes of this questionnaire. This definition is from NCHRP Report 672.

A roundabout is a form of circular intersection in which traffic travels counterclockwise (in the United States and other right-hand traffic countries) around a central island and in which entering traffic must yield to circulating traffic. Exhibit 1-1 is a drawing of a typical roundabout, annotated to identify the key characteristics. Exhibit 1-2 provides a description of each of the key features.

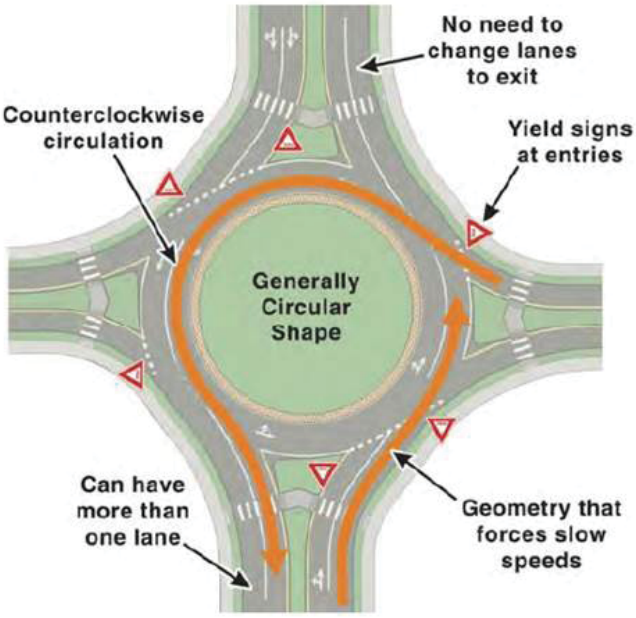

Exhibit 1-1
Key Roundabout Characteristics

Key roundabout features include a generally circular shape, yield control of entering traffic, and geometric curvature and features to induce desirable vehicular speeds.

Splitter islands have multiple roles: separate entering and exiting traffic, deflect and slow entering traffic, and provide a pedestrian refuge.

Exhibit 1-1 from *NCHRP Report 672, Roundabouts: An Informational Guide, Second Edition*

Number of Roundabouts

1. **Approximately** what year did your state agency build its first roundabout? *

- Our agency has not built a roundabout
- Our agency has planned or designed a roundabout, but not yet built a roundabout
- Year *

Roundabout Categories

The figure below provides the design characteristics of the three roundabout categories. This definition should be used for the following questions.

Please note that mini-roundabouts are defined as "small roundabouts with a fully traversable central island," and are unique from neighborhood traffic calming circles. For more information on the difference between mini-roundabouts and neighborhood traffic calming circles, please see NCHRP Report 672.

Exhibit 1-9
Roundabout Category Comparison

Design characteristics of the three roundabout categories.

Design Element	Mini-Roundabout	Single-Lane Roundabout	Multilane Roundabout
Desirable maximum entry design speed	15 to 20 mph (25 to 30 km/h)	20 to 25 mph (30 to 40 km/h)	25 to 30 mph (40 to 50 km/h)
Maximum number of entering lanes per approach	1	1	2+
Typical inscribed circle diameter	45 to 90 ft (13 to 27 m)	90 to 180 ft (27 to 55 m)	150 to 300 ft (46 to 91 m)
Central island treatment	Fully traversable	Raised (may have traversable apron)	Raised (may have traversable apron)
Typical daily service volumes on 4-leg roundabout below which may be expected to operate without requiring a detailed capacity analysis (veh/day)*	Up to approximately 15,000	Up to approximately 25,000	Up to approximately 45,000 for two-lane roundabout

*Operational analysis needed to verify upper limit for specific applications or for roundabouts with more than two lanes or four legs.

Exhibit 1-9 from *NCHRP Report 672, Roundabouts: An Informational Guide, Second Edition*

2. By roundabout category, **approximately** how many roundabouts have been opened within your state and/or by your state agency (roundabouts that your state has jurisdiction over and/or were built as part of projects overseen by your state agency)?

	Mini-Roundabouts	Single-Lane Roundabouts	Multilane Roundabouts
Within your state			
By your state agency (roundabouts that your state has jurisdiction over and/or were built as part of projects overseen by your state agency)			

Roundabout Category by Developed Envrionments

3. By roundabout category, **approximately** what proportion of **mini-roundabouts** are in urban, suburban and rural areas of your state?

	Mini-Roundabouts
Urban	None / Some / Most / All
Suburban	None / Some / Most / All
Rural	None / Some / Most / All

4. By roundabout category, **approximately** what proportion of **single-lane** roundabouts are in urban, suburban and rural areas of your state?

	Single-Lane Roundabouts
Urban	None / Some / Most / All
Suburban	None / Some / Most / All
Rural	None / Some / Most / All

5. By roundabout category, **approximately** what proportion of **multilane** roundabouts are in urban, suburban and rural areas of your state?

	Multilane Roundabouts
Urban	None / Some / Most / All
Suburban	None / Some / Most / All
Rural	None / Some / Most / All

Roundabout Database

6. Do you maintain a database listing roundabouts in your state? This could refer to either all roundabouts in your state, or only roundabouts built by or under the jurisdiction of your state agency.

- Yes
- No

Reasons for selection

7. Please describe the primary reasons why your agency builds roundabouts. Consider each reason and indicate the **approximate** frequency with which roundabouts are built.

	Never	Seldom	About half the time	Usually	Always
Improved safety performance	○	○	○	○	○
Shorter vehicular delays	○	○	○	○	○
Higher capacity	○	○	○	○	○
Lower initial capital costs	○	○	○	○	○
Lower life-cycle costs	○	○	○	○	○
Aesthetic/urban design improvements	○	○	○	○	○
Responding to request from local jurisdiction	○	○	○	○	○
Responding to request from elected official	○	○	○	○	○
Lower speeds/traffic calming	○	○	○	○	○
Other, please explain in the comments box	○	○	○	○	○

Comments

8. Has your state agency installed a roundabout at a location that previously involved one or more fatal crashes in the before condition?

- ○ Yes
- ○ No
- ○ Don't know

Roundabout Considerations

9. Please indicate the types of public outreach materials that have been developed by your state agency. Please select all that apply.

- ☐ Website
- ☐ Flyer and/or pamphlet
- ☐ Video
- ☐ Our state agency has not developed public outreach material
- ☐ Other, please specify *

10. Please indicate the strategies typically used by your state agency at public information open houses:

- [ ] Presentations
- [ ] Charts, figures, etc... on display boards
- [ ] Scaled plan sets with vehicle models
- [ ] Attendance from agency staff
- [ ] Attendance from roundabout design team
- [ ] Attendance from "high-ranking" agency official
- [ ] Attendance from traffic engineers involved in the project
- [ ] Attendance from transportation planners involved in the project
- [ ] Question and answer session (town hall meeting)
- [ ] Flyer and/or pamphlet
- [ ] Video
- [ ] Video of roundabout simulation
- [ ] Our state agency does not typically use public information open houses for roundabout projects
- [ ] Other, please specify *

11. Does your state have state statutes, codes, or laws that regulate traffic rules at roundabouts? More specifically, does your state have state statutes, codes, or laws that are only applicable to roundabouts?

- ○ No
- ○ Yes

Roundabout Costs

12. What is the **approximate** planning-level cost estimate (screening or feasibility level estimate) of a **mini** roundabout in your state? Please limit your responses to "single-purpose" intersection projects.

	Approximate Planning-Level Cost Estimate
Mini Roundabout	

13. What is the **approximate** planning-level cost estimate (screening or feasibility level estimate) of a **single-lane** roundabout in your state? Please limit your responses to "single-purpose" intersection projects.

	Approximate Planning-Level Cost Estimate
Single-Lane Roundabout	

14. What is the **approximate** planning-level cost estimate (screening or feasibility level estimate) of a **multilane** roundabout in your state? Please limit your responses to "single-purpose" intersection projects.

	Approximate Planning-Level Cost Estimate
Multilane Roundabout	

Roundabout Performance

15. What delay/capacity model is used or permitted by your state agency to determine the operational performance of a roundabout? Please select all that apply.

- ☐ HCM 2010 Model
- ☐ HCM 2010 Model calibrated to local conditions
- ☐ HCM 2010 Model calibrated to non-local conditions
- ☐ Sidra Standard Model with Environment Factor
- ☐ Sidra Standard Model without Environment Factor
- ☐ UK Equations uncalibrated
- ☐ UK Equations calibrated
- ☐ Microsimulation
- ☐ Other *

16. What software tools are used by your state agency to determine the operational performance of a roundabout? Please check all that apply.

- ☐ Arcady
- ☐ HCS
- ☐ Rodel
- ☐ Sidra
- ☐ State Agency developed tool (excel spreadsheet or other, please specify)
- ☐ Synchro
- ☐ Vistro
- ☐ Microsimulation
- ☐ Other, please specify in the comments box

Comments

17. How is the design year determined?

- [ ] Case-by-case basis
- [ ] Practical Design policy
- [ ] Specific criteria, please specify the criteria _____ *
- [ ] Fixed design year, please specify the design year _____ *
- [ ] Fixed duration (e.g. 20 years), please specify the number of years _____ *

18. Please provide us an **approximation** of how often the following design-year options are used.

	Never	Seldom	Sometimes	Usually	Always
5 years	○	○	○	○	○
10 years	○	○	○	○	○
20 years	○	○	○	○	○
Over 20 years	○	○	○	○	○

19. How does your state estimate or predict safety at roundabouts?

- [ ] Our state does not typically estimate or predict safety at roundabouts
- [ ] Highway Safety Manual predictive methodology
- [ ] Crash Modification Factors or Crash Reduction Factors (uncalibrated)
- [ ] Crash Modification Factors or Crash Reduction Factors (calibrated to local conditions)
- [ ] Other, please specify _____ *

Roundabout Design

20. Please indicate the extent to which your state agency uses *NCHRP Report 672: Roundabouts an Informational Guide, Second Edition* to provide roundabout design guidance.

- ○ Our state uses NCHRP Report 672 as the only source of design guidance.
- ○ Our state has developed guidance to supplement NCHRP Report 672. Please provide this supplemental guidance in the following question.
- ○ Our state uses NCHRP Report 672 supplemented by material from other sources to provide design guidance. Please indicate what other material is used in the following question.
- ○ Our state has developed separate guidance and does not use, or rarely uses, NCHRP Report 672. Please provide this guidance in the following question.
- ○ Our state uses material from other sources, and does not use, or rarely uses, NCHRP Report 672. Please provide this material in the following question.

21. Please upload the guidance developed by your agency, or if the material is available online, please provide the URL in the comment box.

Browse... Choose File No file selected Upload

Comments

22. Please indicate the sources used for design guidance. If the material is available online, please provide the URL (optional) of the website as well.

	Source	URL (optional)
Source 1		
Source 2		
Source 3		
Source 4		

Phased Implementation

23. Does your state agency typically try to use a phased implementation approach to multilane roundabouts? (This could include opening a roundabout with fewer entry, circulating or exit lanes than is ultimately determined to be necessary for future conditions.)

- Yes
- No

24. Do you have criteria for determining when a phased-implementation approach should be used?

- Yes, please explain in the comments box
- No

Comments

25. Have one or more roundabouts in your state (built by your state agency or others) designed with a phased approach in mind been expanded from its opening-year configuration?

- Yes, please provide intersection(s) in comment box
- No

Comments

26. Have one or more roundabouts in your state (built by your state agency or others) been modified from its original design to address safety or operational issues?

- Yes, please provide intersection(s) in comment box
- No

Comments

Design-Vehicle Guidance

27. Has your state developed guidance on the accommodation of large vehicles (trucks, emergency vehicles, farming equipment, oversize/overweight vehicles, etc...) at roundabouts?

- Yes
- No

28. Is the design-vehicle accommodation guidance provided in the material uploaded in question 19?

- ○ No
- ○ Yes, please provide the document name where we can find the information *

29. Please upload the design-vehicle guidance developed by your agency, or if the material is also available online, please provide the URL in the comment box.

Browse... Choose File No file selected Upload

Comments

30. Please upload the design-vehicle guidance developed by your agency, or if the material is also available online, please provide the URL in the comment box.

Browse... Choose File No file selected Upload

Comments

Illumination Guidance

31. Does your state follow developed standards/guidance on the illumination of roundabouts?

- ○ Yes
- ○ No

32. What is the basis for your state's illumination standard/guidance? Please select all that apply.

- ☐ AASHTO Roadway Lighting Design Guide
- ☐ IES Design Guide for Roundabout Lighting
- ☐ NCHRP Report 672
- ☐ State-specific standard
- ☐ Other, please specify

33. Is the illumination guidance provided in the material uploaded in question 19?

- No
- Yes, please provide the document name where we can find the information *

34. Please upload the illumination guidance developed by your agency, or if the material is also available online, please provide the URL in the comment box.

Browse... Choose File No file selected Upload

Comments

35. Please upload the illumination guidance developed by your agency, or if the material is also available online, please provide the URL in the comment box.

Browse... Choose File No file selected Upload

Comments

States Without Roundabouts

36. What are the major reasons why your agency has not built roundabouts on the state system?

- [ ] They are not part of design standards used by our agency
- [ ] Not sure they work efficiently
- [ ] Not sure they are safe
- [ ] Not sure that the drivers will get used to them
- [ ] Concerned about liability issues
- [ ] Other, please explain *

37. Is your agency considering the construction of roundabouts?

- Yes
- No

Thank You!

Thank you for taking our survey. Your response is very important to us. If you have additional questions or would like to follow-up on the questionnaire, please contact the Principal Investigator, Alek Pochowski at:

- E-mail: *apochowski@kittelson.com*
- Phone: 202-642-2916
- Mailing Address: c/o Kittelson & Associates, Inc.; 300 M ST SE, Suite 810; Washington D.C. 20003

APPENDIX C

Questionnaire Responses

State	Approximately what year did your state agency build its first roundabout?	By roundabout category, approximately how many roundabouts have been opened within your state.			By roundabout category, approximately how many roundabouts have been opened by your state agency (roundabouts that your state has jurisdiction over and/or were built as part of projects overseen by your state agency)?		
		Mini-Roundabouts	*Single-Lane Roundabouts*	*Multilane Roundabouts*	*Mini-Roundabouts*	*Single-Lane Roundabouts*	*Multilane Roundabouts*
Alaska	2001	3	20	9	0	11	7
Arkansas	2008	0	25	0	0	0	4
California	1993	No answer	253	44	0	11	12
Connecticut	2007	2	20	2	0	3	1
Delaware	2004	1	11	1	1	11	1
Florida	1996	4	13	11	0	11	3
Georgia	1999	3	130	2	2	20	0
Idaho	A	No answer	No answer	No answer	No answer	No answer	No answer
Illinois	2006	No answer	No answer	No answer	No answer	No answer	No answer
Indiana	2008	0	122	39	0	5	9
Iowa	2006	10	37	9	0	7	0
Kansas	2000	No answer	77	34	0	13	7
Kentucky	2002	0	10	1	No answer	9	
Louisiana	2002	No answer	No answer	No answer	0	22	1
Maine	2001	No answer	19	5	No answer	19	5
Maryland	1992	10	114	37	1	53	24
Massachusetts	2010	No answer	No answer	No answer	0	4	2
Michigan	2005	1	50	30	0	10	15
Minnesota	2002	2	107	32	0	24	9
Mississippi	2001	30	20	6	0	3	3
Missouri	2000	5	200	20	1	55	15
Montana	2007	1	20	12	0	10	10
Nebraska	2005	No answer	6	4	No answer	6	2
Nevada	2010	No answer	10	4	No answer	4	No answer
New Hampshire	2007	0	28	6	0	8	1
New Mexico	2000	No answer	15	15	No answer	10	10
New York	2000	2	100	25	0	65	25
North Carolina	1999	0	229	18	0	120	16
North Dakota	2012	10	2	No answer	No answer	1	No answer
Oregon	1999	0	60	10	0	1	1
Pennsylvania	2005	0	20	1	0	17	1
Rhode Island	2003	No answer	3	3	No answer	No answer	No answer
South Dakota	B	No answer	3	0	0	0	0
Texas	1996	No answer	No answer	No answer	No answer	No answer	No answer
Vermont	1993	1	12	1	0	6	1
Virginia	2002	No answer	145	15	No answer	110	5
Washington	1997	9	210	85	4	80	30
West Virginia	2010	0	5	4	0	0	4
Wisconsin	1999	0	154	175	0	100	147
Wyoming	2010	No answer	No answer	No answer	0	5	0

A: Our agency has not built a roundabout
B: Our agency has planned or designed a roundabout, but not yet built a roundabout

State	By roundabout category, approximately what proportion of mini-roundabouts are in urban, suburban and rural areas of your state?			By roundabout category, approximately what proportion of single lane roundabouts are in urban, suburban and rural areas of your state?			By roundabout category, approximately what proportion of multilane roundabouts are in urban, suburban and rural areas of your state?			Do you maintain a database listing roundabouts in your state?
	Urban	*Suburban*	*Rural*	*Urban*	*Suburban*	*Rural*	*Urban*	*Suburban*	*Rural*	
Alaska	All	None	None	Most	Some	Some	Some	Some	None	Yes
Arkansas				Most	Some	Some	All	None	None	Yes
California	None	None	None	Some	Most	Some	Some	Most	None	Yes
Connecticut	All	None	None	Some	Most	Some	None	All	None	Yes
Delaware	All	None	None	Some	Some	Most	All	None	None	Yes
Florida	Some	Most	None	Most	Most	All	Most	Most	All	Yes
Georgia	Most		Some	Some	Some	Some		Some	Some	Yes
Idaho										
Illinois										
Indiana	None	None	None	Some	Most	Some	Some	Most	Some	No
Iowa	Some	Most	None	Some	Most	Some	Some	Most	None	Yes
Kansas				Most	Some	Some	Most	Some	None	Yes
Kentucky	None	None	None	Some	Most	Some	None	All	None	No
Louisiana	None	None	None	Some	Most	Some	None	None	All	Yes
Maine	None	None	None	Some	Most	Some	Most	Some		Yes
Maryland	Most	Some	None	Some	Most	Most	Some	Most	Some	Yes
Massachusetts	None	None	None	Some	Some	None	Some	Some	None	No
Michigan	None	Most	Some	Some	Some	Some	Most	Some	Some	Yes
Minnesota	Most	Most	None	Most	Some	Some	Most	Some	Some	Yes
Mississippi	Some	Most		Most	Some		All			No
Missouri	Most	None	Some	Most	Some	Some	Most	Some	None	No
Montana	All	None	None	Some	Most	Some	All	None	None	Yes
Nebraska	All	None	None	Some	Some	Some	Some	Some	None	No
Nevada	None	None	None	Some	Some	Some	None	None	None	No
New Hampshire	None	None	None	Some	Most	Some	Some	Some	None	Yes
New Mexico	Most	Some	None	Most	Some	None	All			No
New York	None	All	None	Some	Most	Some	Some	Most	Some	Yes
North Carolina	None	None	None	Some	Most	Some	Some	Most	None	Yes
North Dakota	Some	Some		Some		Most	None	None	None	No
Oregon	None	None	None	Some	Most	Some	None	All	None	No
Pennsylvania	None	None	None	Some	Some	Most	None	None	All	No
Rhode Island	All	None	None	All	None	None	None	All	None	Yes
South Dakota	None	None	None	All	None	None	None	None	None	No
Texas										No
Vermont	All	None	None	Some	Some	Some	All	None	None	No
Virginia				Some	Most	Some	Some	Most	Some	Yes
Washington	Some	Some	Some	Most	Some	Some	Some	Most	Some	Yes
West Virginia				Most	Some	None	Most	Some	None	No
Wisconsin	None	None	None	Some	Some	Most	Some	Most	Some	Yes
Wyoming	None	None	None	Some	Some	Some	None	None	None	Yes

State	Please select the frequency in which your state agency selects roundabouts based on the following set of common reasons for selecting roundabouts.											Has your state agency installed a roundabout at a location that previously involved one or more fatal crashes in the before condition?
	Improved safety performance	*Shorter vehicular delays*	*Higher capacity*	*Lower initial capital costs*	*Lower life-cycle costs*	*Aesthetic/urban design improvements*	*Responding to request from local jurisdiction*	*Responding to request from elected official*	*Lower speeds/traffic calming*	*Other*	*Other Note*	
Alaska	Usually	Usually	About half the time	About half the time	Usually	Usually	Seldom	Seldom	Seldom			No
Arkansas	Seldom	About half the time	About half the time	Never	About half the time	About half the time	Usually	About half the time	Seldom			No
California	About half the time	Usually	About half the time	Seldom	Never	About half the time	Seldom	Never	Seldom			Yes
Connecticut	Always	About half the time	Seldom	Seldom	About half the time	About half the time	About half the time	About half the time	Usually			Yes
Delaware	About half the time	About half the time	About half the time	Never	Never	About half the time	Never	Never	About half the time		A	Don't know
Florida	Usually	About half the time	Seldom	About half the time	Seldom	About half the time	About half the time	Seldom	About half the time	Always	B	No
Georgia	Usually	About half the time	About half the time	About half the time	About half the time	About half the time	Usually	About half the time	About half the time			Yes
Idaho												
Illinois												
Indiana	Usually	About half the time	About half the time	Seldom	About half the time	Seldom	Seldom	Seldom	Seldom			Don't know
Iowa	Usually	About half the time	About half the time	Seldom	Seldom	Seldom	Never	Never	About half the time			Yes
Kansas	Always	Usually	Usually	Always	Always	About half the time	Always	Always	Always	Always	C	Yes
Kentucky	Usually	About half the time	Usually	About half the time	About half the time	About half the time	About half the time	About half the time	Usually			Yes
Louisiana	Usually	Usually	Usually	Seldom	About half the time	Seldom	Usually	Usually	Usually			Yes
Maine	Usually	Usually	Usually	Seldom	Seldom	Seldom	Usually	Seldom	Usually			Yes
Maryland	Usually	Usually	Usually	Never	About half the time	About half the time	Seldom	Seldom	Never			Yes
Massachusetts	Always	Usually	Usually	Usually	Usually	Seldom	About half the time	Seldom	Usually			Don't know
Michigan	Usually	Usually	Usually	About half the time	About half the time	About half the time	About half the time	Seldom	Seldom			Yes
Minnesota	Usually	Usually	Usually	Seldom	About half the time	About half the time	Seldom	Seldom	Usually			Yes
Mississippi	About half the time	Usually	About half the time	Seldom	About half the time	Seldom	Never		About half the time			No
Missouri	Usually	Seldom	About half the time	Seldom	About half the time	About half the time	About half the time	About half the time	Seldom			Yes
Montana	Always	Usually	Usually	Seldom	Usually	About half the time	About half the time	Seldom	Seldom			Yes
Nebraska	Usually	Seldom	Seldom	Seldom	Seldom	Seldom	Seldom	Seldom	Seldom			Yes
Nevada	Usually	Seldom	Seldom	Never	Seldom	Never	Never	Never	About half the time			Don't know
New Hampshire	Usually	Usually	Usually	Seldom	About half the time	About half the time	About half the time	Seldom	Usually			Yes
New Mexico	Usually	Usually	Usually	Seldom	Seldom	Seldom	Usually	Usually	Usually			Don't know
New York	Usually	Usually	Usually	Seldom	Usually	Usually	Seldom	Seldom	Usually	About half the time	D	Yes
North Carolina	Always	Usually	Seldom	Seldom	About half the time	Seldom	About half the time	Seldom	Seldom	Seldom	E	Yes
North Dakota	Always	Usually	Usually	Seldom	Seldom	Seldom	About half the time	Never	Usually			Don't know
Oregon	Usually	Usually	Usually	Seldom	Usually	Usually	Usually	Usually	Usually			Yes
Pennsylvania	Usually	About half the time	About half the time	Never	Seldom	Never	Seldom	Seldom	Seldom			Yes
Rhode Island	Always	Always	Always	Seldom	Seldom	About half the time	About half the time	Seldom	About half the time			No
South Dakota	Always	Always	About half the time	Never	Always	Never	Seldom	Seldom	About half the time		F	No
Texas											G	Don't know
Vermont	Always	Usually	Seldom	Seldom	Seldom	Never	Never	Never	Usually	Never		Yes
Virginia	Always	Always	Always	Always	Always	Always	Always	Always	Always			Yes
Washington	Usually	Usually	Usually		Usually	Usually	Usually	Usually			H	Yes
West Virginia	Usually	Usually	Usually	Never	About half the time		Seldom	Seldom	Seldom			No
Wisconsin	Usually	Usually	Usually	Seldom	Seldom	Seldom	Seldom	Seldom	Seldom			Yes
Wyoming	Usually	Usually	Seldom	Never	Never	Never	Never	Never	Never			No

A: Lower off-peak delays than a traffic signal
B: FDOT directive to consider roundabouts when doing a project
C: Our primary goal is improved safety.
D: Quite a few of our roundabouts come to be once a project has been started for a safety or capacity concern - we typically don't have "roundabout" projects.
E: Design decision - roundabouts at intersections next to a bridge that can eliminate a turn lane on the bridge (both in retrofit and new installations). Likewise on corridors to eliminate turn lanes (narrower corridor).
F: These are reasons roundabouts have been proposed or designed, as we have not actually constructed any yet.
G: Unknown
H: "Usually" for All of the reasons with the exception being lower initial costs

State	Please indicate the types of public outreach materials that have been developed by your state agency. Please select all that apply.					
	Website	*Flyer and/or pamphlet*	*Video*	*Other*	*Other Note*	*Our state agency has not developed public outreach material*
Alaska	X	X				
Arkansas	X	X	X			
California	X	X	X			
Connecticut	X	X				
Delaware	X	X	X			
Florida		X	X			
Georgia	X	X				
Idaho						
Illinois		X				
Indiana	X	X	X			
Iowa	X	X				
Kansas	X	X	X	X	A	
Kentucky		X	X			
Louisiana	X	X				
Maine	X	X	X			
Maryland	X	X				
Massachusetts						X
Michigan	X	X	X			
Minnesota	X	X	X	X	B	
Mississippi						X
Missouri	X	X	X			
Montana	X	X				
Nebraska	X	X	X	X	C	
Nevada						X
New Hampshire		X				
New Mexico	X	X	X			
New York	X	X		X	D	
North Carolina		X				
North Dakota	X		X			
Oregon	X	X	X			
Pennsylvania	X	X				
Rhode Island	X	X				
South Dakota	X					
Texas						X
Vermont	X	X	X			
Virginia	X	X	X			
Washington				X		
West Virginia	X	X	X			
Wisconsin	X	X	X	X	E	
Wyoming	X	X	X			

A: Public meetings with displays
B: Roundabout mat (scale model); roundabout guidance on state highway map
C: Radio and TV public-service announcements
D: VISSIM simulations
E: Wisconsin Motorist Handbook, TV & radio commercials, video animation, roundabout driver simulator, DVD's, state maps, Commerical Driver's Manual, newpaper articles

State	Please indicate the strategies typically used by your state agency at public information open houses														
	Presentations	*Charts, figures, etc... on display boards*	*Scaled plan sets with vehicle models*	*Attendance from agency staff*	*Attendance from roundabout design team*	*Attendance from "high-ranking" agency official*	*Attendance from traffic engineers involved in the project*	*Attendance from transportation planners involved in the project*	*Question and answer session (town hall meeting)*	*Flyer and/or pamphlet*	*Video*	*Video of roundabout simulation*	*Other*	*Other Note*	*Our state agency does not typically use public information open houses for roundabout projects*
Alaska	X	X	X	X	X	X	X			X					
Arkansas	X	X	X	X	X	X	X	X	X	X	X	X			
California	X	X		X	X		X	X	X	X	X	X			
Connecticut	X			X	X		X		X	X	X	X			
Delaware	X	X	X	X	X		X	X	X	X	X	X			
Florida	X	X	X	X	X		X	X	X	X	X	X			
Georgia		X	X	X	X		X	X		X	X	X			
Idaho															
Illinois	X														
Indiana	X	X		X	X	X	X	X	X	X	X	X			
Iowa		X		X	X			X		X					
Kansas	X	X		X	X	X	X	X	X	X	X	X			
Kentucky	X	X		X	X		X	X		X	X	X			
Louisiana	X	X	X	X	X	X	X		X	X	X	X			
Maine	X		X	X	X	X	X	X	X	X	X	X			
Maryland	X	X	X	X	X	X	X	X	X	X	X	X			
Massachusetts	X	X		X	X		X	X							
Michigan	X	X	X	X	X		X	X	X	X	X	X			
Minnesota	X	X	X	X	X		X		X	X	X	X	X	A	
Mississippi	X	X		X		X	X	X		X		X			
Missouri	X	X	X	X			X	X				X			
Montana	X	X		X	X	X	X		X	X	X	X			
Nebraska	X	X	X	X	X	X	X		X	X	X	X			
Nevada	X			X			X	X	X						
New Hampshire	X	X	X	X	X	X	X	X	X	X		X			
New Mexico	X	X	X	X	X		X	X	X	X	X	X			
New York	X	X		X	X	X	X	X	X	X	X	X			
North Carolina	X			X	X		X	X	X	X	X				
North Dakota	X	X		X	X	X	X		X	X		X			
Oregon	X	X	X	X	X		X	X	X	X	X	X			
Pennsylvania	X	X	X	X	X	X	X	X	X	X	X	X			
Rhode Island	X	X	X	X	X		X		X	X	X				
South Dakota	X	X	X	X	X	X	X	X	X	X	X	X			
Texas															X
Vermont	X	X		X	X					X	X	X			
Virginia	X	X		X	X	X	X	X	X	X	X	X			
Washington													X	B	
West Virginia	X	X		X	X	X	X		X	X	X	X			
Wisconsin	X	X	X	X	X	X	X	X	X	X	X	X			
Wyoming	X	X	X	X	X		X			X	X	X			

A: Roundabout mat, mall kiosk, radio & newspaper ads, bus rides, simulator events
B: Design Visualization

State	Does your state have state statutes, codes, or laws that regulate traffic rules at roundabouts? More specifically, does your state have state statutes, codes, or laws that are only applicable to roundabouts?	What is the approximate planning-level cost estimate (screening or feasibility level estimate) of a roundabout by category in your state? Please limit your responses to "single-purpose" intersection projects.		
		Mini-Roundabouts	*Single-Lane Roundabouts*	*Multilane Roundabouts*
Alaska	Yes	No answer	$1,500,000	$3,000,000.00
Arkansas	No	No answer	$500,000	$1,250,000.00
California	No	No answer	$1,500,000	$3,000,000.00
Connecticut	No	No answer	$1,500,000	$2,000,000.00
Delaware	No	No answer	$2,000,000	No answer
Florida	Yes	$50,000	$500,000	$1,200,000.00
Georgia	No	$200,000	$1,200,000	$2,000,000.00
Idaho		No answer	No answer	No answer
Illinois		No answer	No answer	No answer
Indiana	Yes	No answer	$635,000	$1,400,000.00
Iowa	No	No answer	No answer	No answer
Kansas	Yes	No answer	$2,500,000	$4,000,000.00
Kentucky	No	No answer	$100,000	$200,000.00
Louisiana	No	No answer	$1,600,000	$3,000,000.00
Maine	Yes	No answer	$1,300,000	$2,500,000.00
Maryland	Yes	$400,000	$1,000,000	$2,500,000.00
Massachusetts	No	No answer	No answer	No answer
Michigan	No	No answer	No answer	No answer
Minnesota	Yes	$160,000	$1,050,000	$1,500,000.00
Mississippi	No	$250,000	$2,000,000	$3,000,000.00
Missouri	No	$50,000	$600,000	$800,000.00
Montana	Yes	No answer	$2,000,000	$2,500,000.00
Nebraska	No	No answer	No answer	No answer
Nevada	No	No answer	$1,500,000	$6,000,000.00
New Hampshire	No	No answer	$1,000,000	$2,000,000.00
New Mexico	No	No answer	$750,000	$750,000.00
New York	Yes	$50,000	$1,000,000	$1,500,000.00
North Carolina	No	$250,000	$600,000	$1,000,000.00
North Dakota	No	$1,000,000	$2,000,000	No answer
Oregon	Yes	No answer	No answer	No answer
Pennsylvania	No	No answer	No answer	No answer
Rhode Island	No	No answer	No answer	No answer
South Dakota	No	No answer	$1,000,000	No answer
Texas	No	No answer	No answer	No answer
Vermont	Yes	No answer	No answer	No answer
Virginia	Yes	No answer	$1,500,000	$2,500,000.00
Washington	No	$80,000	$1,250,000	$1,750,000.00
West Virginia	No	No answer	$400,000	$600,000.00
Wisconsin	No	No answer	$100,000	$1,250,000.00
Wyoming	No	No answer	$5,000,000	No answer

State	What delay/capacity model is used or permitted by your state agency to determine the operational performance of a roundabout? Please select all that apply.									
	HCM 2010 Model	*HCM 2010 Model calibrated to local conditions*	*HCM 2010 Model calibrated to non-local conditions*	*Sidra Standard Model with Environment Factor*	*Sidra Standard Model without Environment Factor*	*UK Equations uncalibrated*	*UK Equations calibrated*	*Microsimulation*	*Other*	*Other Note*
Alaska	X			X		X				
Arkansas	X	X			X			X	X	A
California	X	X		X			X	X		
Connecticut								X		
Delaware	X							X		
Florida	X			X				X	X	B
Georgia	X	X	X	X	X			X	X	C
Idaho										
Illinois	X									
Indiana		X		X					X	D
Iowa					X			X		
Kansas		X		X			X	X		
Kentucky	X							X	X	E
Louisiana				X				X		
Maine	X				X					
Maryland	X			X				X		
Massachusetts				X				X		
Michigan										
Minnesota	X	X				X		X	X	F
Mississippi	X	X		X	X		X			
Missouri	X				X					
Montana					X		X	X		
Nebraska										
Nevada					X					
New Hampshire	X	X		X						
New Mexico	X			X				X		
New York				X				X	X	
North Carolina				X				X		
North Dakota	X							X		
Oregon	X							X		
Pennsylvania	X	X								
Rhode Island	X			X						
South Dakota		X			X					
Texas	X	X	X	X	X					
Vermont	X				X					
Virginia				X				X		
Washington				X	X				X	G
West Virginia	X									
Wisconsin		X		X		X		X	X	H
Wyoming				X	X					

A: RODEL
B: Synchro
C: Model used depends on build year or future vs. year evaluation
D: Vissim traffic simulation, Synchro SimTraffic
E: Equations provided in NCHRP Report 572
F: Rodel, Arcady
G: Sidra Standard with no environment factor in design year
H: HCM 2010 model calibrated for statewide roundabout analysis based on observed headways

State	What software tools are used by your state agency to determine the operational performance of a roundabout? Please check all that apply.									
	Arcady	*HCS*	*Rodel*	*Sidra*	*State Agency developed tool (excel spreadsheet or other, please specify)*	*Synchro*	*Vistro*	*Microsimulation*	*Other, please specify in the comments box*	*Comments*
Alaska		X	X	X		X				
Arkansas		X	X			X		X		
California		X	X	X		X		X		
Connecticut							X	X	X	A
Delaware		X						X		
Florida		X		X		X	X	X	X	A
Georgia	X			X	X			X		B
Idaho										
Illinois				X						
Indiana				X						
Iowa				X		X		X		
Kansas		X	X	X				X		
Kentucky		X	X			X		X	X	C
Louisiana				X					X	A
Maine	X	X		X		X				
Maryland		X		X				X		
Massachusetts				X				X		
Michigan			X							
Minnesota	X	X	X		X			X		D
Mississippi		X		X		X				
Missouri				X		X		X		
Montana				X		X		X		
Nebraska										
Nevada				X						
New Hampshire				X		X				
New Mexico		X		X		X		X		
New York				X				X		
North Carolina				X				X		E
North Dakota		X				X		X		
Oregon					X	X		X	X	F
Pennsylvania		X				X				
Rhode Island				X		X				
South Dakota		X		X						
Texas		X		X						
Vermont				X		X		X		
Virginia				X				X		A
Washington										G
West Virginia		X		X		X				
Wisconsin		X	X	X		X		X		H
Wyoming		X		X		X		X		

A: Vissim
B: GDOT Roundbout Analysis tool is almost always used, so HCS is not used much since the GDOT tool uses the same formulas. Arcady is approved, but rarely used. Sidra is the most common software used. Vissim has been used.
C: HCS is main software used.
D: Our Road Design Manual recommends use of the UK model (Arcady, Rodel). However, when capacity threshold is in question, we also check and compare with HCM and microsimulation/Vissim results.
E: We currently only accept SIDRA analysis for determining LOS or capacity. We will use SimTraffic to see how a roundabout may work in a road network, but do not accept Synchro analysis (v. 7, we are evaluation v. 9.) We did not accept HCM2000, but are evaluating HCM2010. VISSIM and Trans-Modeler have been used for LOS and capacity decisions.
F: Excel spreadsheet
G: Rodel and Sidra. We don't accept Synchro
H: Synchro used in combination with Microsimulation. Rodel has been used in the past.

State	How is the design year determined?								
	Case-by-case basis: Please provide us an approximation of how often the following design-year options are used.					*Practical Design policy*	*Specific criteria, please specify the criteria:*	*Fixed design year, please specify the design year:*	*Fixed duration (e.g. 20 years), please specify the number of years:*
	Case-by-case basis	*5 years*	*10 years*	*20 years*	*Over 20 years*				
Alaska									20
Arkansas									20
California								C	D
Connecticut									20
Delaware									20
Florida									20
Georgia	X	Never	Sometimes	Usually	Seldom				20
Idaho									
Illinois									
Indiana									20
Iowa									20
Kansas									E
Kentucky									25
Louisiana									15-20
Maine									20
Maryland									20
Massachusetts	X	Never	Sometimes	Sometimes	Never				
Michigan									20
Minnesota			Usually	Always		X	A		
Mississippi									F
Missouri									20
Montana									20
Nebraska									20
Nevada	X	Seldom	Seldom	Usually	Seldom				
New Hampshire									20
New Mexico				Usually		X			
New York									G
North Carolina	X	Seldom	Sometimes	Usually	Never				
North Dakota		Never	Never	Always	Never	X			
Oregon									H
Pennsylvania									20
Rhode Island	X	Seldom	Seldom	Usually	Sometimes				
South Dakota									20
Texas	X								
Vermont				Always		X			
Virginia									30
Washington							B		I
West Virginia	X	Always	Usually	Usually	Seldom				20
Wisconsin									20
Wyoming									20

A: 20 year design life; then a phased approach based on 10 year increments
B: 20 years for Federal or Interstate projects
C: Current year for safety & operational projects; build-out year for local development mitigation projects
D: 20 years from construction for new facility or reconstruction (intersection and interchange)
E: 20 years or full buildout (30-40 years)
F: Typically 20 years for new construction; 10 years for 3R (Resurfacing, Restoration, Rehabilitation) projects
G: 10 and 20 - phased in design. 30 if bridge involved.
H: 20 years, 10 years for development
I: Usually 20 years however with Practical Design, are looking at 10 year windows

State	How does your state estimate or predict safety at roundabouts?					
	Highway Safety Manual predictive methodology:	*Crash Modification Factors or Crash Reduction Factors (uncalibrated):*	*Crash Modification Factors or Crash Reduction Factors (calibrated to local conditions):*	*Other*	*Other, please specify*	*Our state does not typically estimate or predict safety at roundabouts*
Alaska		X				
Arkansas		X				
California				X	A	
Connecticut				X	B	
Delaware	X					
Florida	X	X	X			
Georgia		X	X	X	C	
Idaho						
Illinois						
Indiana				X	D	
Iowa		X				X
Kansas			X	X	E	
Kentucky						X
Louisiana		X				
Maine	X		X			
Maryland	X					
Massachusetts						X
Michigan			X			
Minnesota	X	X	X			
Mississippi	X	X				
Missouri	X					
Montana	X		X			
Nebraska	X	X	X	X	F	
Nevada						X
New Hampshire		X				
New Mexico	X	X				
New York		X		X	G	
North Carolina		X				
North Dakota	X					
Oregon	X		X			
Pennsylvania		X				
Rhode Island						X
South Dakota	X	X				
Texas		X				
Vermont		X				
Virginia	X					
Washington				X	H	
West Virginia	X					
Wisconsin	X	X		X	I	
Wyoming		X				

A: Via "collision rate groups" established from our collision database, adjusted for traffic volumes and development conditions (i.e. rural, suburban, urban)
B: IIHS study
C: The FHWA clearinghouse is typically used
D: Our own highway safety analysis program
E: Before/After Study
F: State evaluation
G: Developing crashes per million entering vehicle rates
H: In addition to HSM predictive methology, we will rely on early IIHS work for rural locations
I: Roundabout safety analyses, phase 1 and 2 (completed; phase 3 forthcoming)

State	Please indicate the extent to which your state agency uses NCHRP Report 672: Roundabouts an Informational Guide, Second Edition to provide roundabout design guidance.					
	Our state uses NCHRP Report 672 as the only source of design guidance.	*Our state uses NCHRP Report 672 supplemented by material from other sources to provide design guidance.*	*Our state has developed guidance to supplement NCHRP Report 672.*	*Our state has developed separate guidance and does not use, or rarely uses, NCHRP Report 672.*	*Our state uses material from other sources, and does not use, or rarely uses, NCHRP Report 672.*	*Please indicate the sources used for design guidance.*
Alaska		X				A
Arkansas		X				B
California			X			
Connecticut	X					
Delaware			X			
Florida			X			
Georgia			X			C
Idaho						
Illinois						
Indiana			X			D
Iowa			X			E
Kansas			X			F
Kentucky					X	G
Louisiana			X			H
Maine	X					
Maryland			X			
Massachusetts	X					
Michigan		X				I
Minnesota			X			J
Mississippi	X					
Missouri		X				K
Montana		X				L
Nebraska						
Nevada		X				M
New Hampshire	X					
New Mexico	X					
New York			X			N
North Carolina	X					
North Dakota		X				O
Oregon			X			P
Pennsylvania	X					
Rhode Island	X					
South Dakota		X				Q
Texas		X				R
Vermont	X					
Virginia	X					
Washington				X		S
West Virginia		X				T
Wisconsin			X			U
Wyoming					X	

A: MUTCD; Memo on design from regional pre-construction engineer
B: Kansas Roundabout Guide
C: Chapter 8 of the Georgia DOT Design Policy Manual (http://www.dot.ga.gov/PartnerSmart/DesignManuals/DesignPolicy/GDOT-DPM.pdf)
D: Indiana DOT - 2013 Design Manual, page 84 (http://www.in.gov/indot/design_manual/files/Ch51_2013.pdf)
E: Iowa DOT Design Manual, Chapter 6, Section 6A-3 (http://www.iowadot.gov/design/dmanual/06a-03.pdf)
F: Kansas Roundabout Guide - 2nd Edition (https://www.ksdot.org/burtrafficeng/roundabouts/roundabout_guide/roundaboutguide.asp
G: NCHRP Report 672; Kentucky Transportation Cabinet Design Guidance (http://transportation.ky.gov/Highway-Design/Memos/Design%2003-10.pdf)
H: Louisiana DOT Road Design Manual, Chapter 6, Section 6.9 (http://wwwsp.dotd.la.gov/Inside_LaDOTD/Divisions/Engineering/Road_Design/Road%20Design%20Manual/09%20Chapter%206%20-%20At-Grade%20Intersections.pdf)
I: Michigan DOT Roundabout Guidance Document (http://mdotcf.state.mi.us/public/tands/Details_Web/mdot_roundabout_guidance_document.pdf)
J: Minnesota DOT Road Design Manual Chpter 12 - Guidelines for Modern Roundabouts (http://dotapp7.dot.state.mn.us/edms/download?docId=1062365)
K: Missouri DOT Engineering Policy Guide - 233.3 Roundabouts (http://epg.modot.mo.gov/index.php?title=233.3_Roundabouts)
L: NHCRP Report 572 Roundabouts in the United States; Roundabout Design Guidelines, Ourston Roundabout Engineering; Synthesis of North American Roundabout Practice, Transportation Association of Canada
M: Roundabouts, An Informational Guide, Publication No. FHWA-RD-00-067; MUTCD, Part 2b & Part 3; NCHRP Report 674, Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians With Vision Disabilities; Roundabout Design Guidelines, Wisconsin DOT
N: Chapters 5, 8, 11, and 18 of the New York State DOT Highway Design Manual (https://www.dot.ny.gov/divisions/engineering/design/dqab/hdm)
O: FHWA; AASHTO
P: Oregon DOT Highway Design Manual (ftp://ftp.odot.state.or.us/techserv/roadway/web_drawings/HDM/2011%20HDM%20Rewrite/2012%20Chapter%208%20Intersections.pdf); Oregon DOT Roundabout Directive DES-02 (http://www.oregon.gov/ODOT/HWY/TECHSERV/docs/pdf/des_02.pdf); Oregon DOT Traffic Manual, Section 6.26 (http://www.oregon.gov/ODOT/HWY/TRAFFIC-ROADWAY/docs/pdf/traffic_manual_13.pdf); Oregon DOT Analysis Procedure Manual (http://www.oregon.gov/ODOT/TD/TP/Pages/apm.aspx)
Q: South Dakota DOT Road Design Manual, Chapter 12 (http://sddot.com/business/design/docs/rd/rdmch12.pdf)
R: Texas Roundabout Guidelines: Final Report (https://www.utexas.edu/research/ctr/pdf_reports/0_6414_1.pdf)
S: Washington DOT Design Manual, Chapter 1320 (http://www.wsdot.wa.gov/publications/manuals/fulltext/M22-01/1320.pdf)
T: AASHTO, A Policy on Geometric Desgin of Highways and Streets "Green Book"
U: Wisconsin DOT Facilities Development Manual, Chapter 11, Section 26 (http://wisconsindot.gov/rdwy/fdm/fd-11-26.pdf#fd11-26)

State	Phased implementation approach to multilane roundabouts				
	Does your state agency typically try to use a phased implementation approach to multilane roundabouts? (This could include opening a roundabout with fewer entry, circulating or exit lanes than is ultimately determined to be necessary for future conditions.)	*Do you have criteria for determining when a phased-implementation approach should be used?*	*Please indicate the criteria used for determining when a phased-implementation approach should be used.*	*Have one or more roundabouts in your state (built by your state agency or others) designed with a phased approach in mind been expanded from its opening-year configuration?*	*Have one or more roundabouts in your state (built by your state agency or others) designed with a phased approach in mind been expanded from its opening-year configuration?: Comments*
Alaska	Yes	No		No	
Arkansas	Yes	Yes	A	No	
California	Yes	Yes		No	
Connecticut	No				
Delaware	No				
Florida	Yes	No		Yes	
Georgia	Yes	Yes	B	No	
Idaho	N/A				
Illinois	N/A				
Indiana	No				
Iowa	Yes	No		No	
Kansas	Yes	Yes	C	No	
Kentucky	Yes	No		No	
Louisiana	Yes	Yes	D	No	
Maine	No				
Maryland	Yes	Yes	E	Yes	M
Massachusetts	No				
Michigan	Yes	Yes	F	No	
Minnesota	Yes	Yes	G	No	
Mississippi	No				
Missouri	Yes	No		No	
Montana	Yes	No	H	No	
Nebraska	No				
Nevada	No				
New Hampshire	Yes	No		No	
New Mexico	Yes	No		No	
New York	Yes	Yes	I	No	
North Carolina	Yes	Yes	J	No	
North Dakota	No				
Oregon	Yes	No		No	
Pennsylvania	No				
Rhode Island	No				
South Dakota	N/A				
Texas	No				
Vermont	No				
Virginia	Yes	No		No	
Washington	Yes		K	Yes	N
West Virginia	Yes	Yes	L	No	
Wisconsin	Yes				
Wyoming	No				

A: It's a case-by-case basis. Modeling is used to project traffic volumes for opening date and 20 year design. Implementation of lane geometry is phased accordingly.
B: If the roundabout will work as a single-lane roundabout for approximately 10 years or more (based on capacity analysis), Georgia DOT opens it as a single-lane roundabout with removable portions for the future multi-lane configuration.
C: Documented in Section 6.1.3 of the Kansas Roundabout Guide, 2nd Edition
D: Analysis output from software.
E: If a single-lane configuration will be sufficient for five years or less Maryland SHA will proposed a multilane configuration. If the single-lane configuration is sufficient for more than ten years, SHA will open as a single-lane roundabout. In between five and ten years is decided on a case-by-case basis.
F: Evaluated on a case-by-case basis depending on the expected traffic volume growth between the opening and design years.
G: If the roundabout will work as a single-lane roundabout for approximately 10 years or more (based on capacity analysis), Michigan DOT opens it as a single-lane roundabout, and waits for future phased construction. Michigan DOT also coordinates the single-lane and multilane designs to minimize future reconstruction.
H: Depends on future capacity needs, and is determined on a case-by-case basis.
I: The roundabout is opened as a single-lane roundabout designed with expansion in mind when New York State DOT predicts a single-lane roundabout will get ten years of acceptable operations, but fail before 20 years
J: For long-range projects, a design year (currently 2040) analysis is done to determine ultimate design. If this design calls for multi-lane approaches or slip lanes, North Carolina DOT will conduct an interim analysis to see if fewer lanes will work for at least ten years or so.
K: The use of a phased-implementation approach is site specific and left up to the judgment of the traffic engineers working with the expected traffic volumes in collaboration with program or project offices involved in developing the project footprint.
L: The use of a phased-implementation approach is sometimes based expected traffic volumes (opening-year volumes versus subsequent future-year volumes) or could be to align future expansion with other roadway work
M: I-495/Ritchie Marlboro Road interchange ramp terminals
N: SR 166/ Bethel Avenue - Port Orchard; SR 501/45th Street - Ridgefield; Boulevard Road/Log Cabin - Olympia

State	Roundabouts modified from its original design to address safety or operational issues	
	Have one or more roundabouts in your state (built by your state agency or others) been modified from its original design to address safety or operational issues?	*Have one or more roundabouts in your state (built by your state agency or others) been modified from its original design to address safety or operational issues?: Comments*
Alaska	Yes	A
Arkansas	No	
California	Yes	B
Connecticut	No	
Delaware	Yes	C
Florida	Yes	D
Georgia	Yes	E
Idaho		
Illinois		
Indiana	No	
Iowa	Yes	F
Kansas	Yes	G
Kentucky	Yes	H
Louisiana	No	
Maine	Yes	I
Maryland	Yes	J
Massachusetts	Yes	K
Michigan	Yes	L
Minnesota	Yes	M
Mississippi	No	
Missouri	No	
Montana	No	
Nebraska	Yes	N
Nevada	No	
New Hampshire	No	
New Mexico	No	
New York	Yes	O
North Carolina	Yes	P
North Dakota	No	
Oregon	Yes	Q
Pennsylvania	No	
Rhode Island	No	
South Dakota	No	
Texas	No	
Vermont	No	
Virginia	Yes	R
Washington	Yes	S
West Virginia	Yes	T
Wisconsin	Yes	U
Wyoming	Yes	V

A: Dowling/New Seward Highway intersection in design
B: State Highway Route 1/Simpson Lane intersection in Mendocino County was modified from a "hybrid" to a single-lane configuration.
C: A roundabout was modified becaues of issues with oversized farm vehicles in a rural area. The roundabout was significantly modified with larger/less steep apron, more clear area on the outside of the roundabout, and less steep curbs
D: Clearwater, Florida
E: Georgia DOT added a truck apron to a roundabout near Gainesville College and modified truck aprons on roundabouts in Culloden and Carrollton due to design vehicle issues
F: US 34/US 63 in Ottumwa
G: US-50/I-35 interchange in Emporia, Kansas
H: The signing and pavement markings of a multilane roundabout were modified by a local jurisdiction
I: The first roundabout built by the Maine DOT did not have a raised truck apron which was added in subsequent years
J: Many early roundabouts have been modified
K: Rotaries have been retrofit with roundabout-style markings to improve safety and reduce delays.
L: M-53/18 ½ Mile Road intersection had revisions to the central island and signing. Other roundabouts have had slight modifications, typically including signing and pavement markings
M: TH61/Broadway Ave, Forest Lake, MN; CR13 (Radio Dr)/CR18 (Bailey Rd), Woodbury, MN; I-35/CR12 (69th ST NW) interchange
N: Multilane roundabout with three lanes at the intersection of 14th Street/Superior Street built by the City of Lincoln was reduced to two lanes.
O: So far just signing, striping, and lane assignment modifications. New York State DOT will likely start reducing lanes based on growth rate predictions not coming to fruition.
P: Hillsborough St. at Pullen/Oberlin intersection in Raleigh. Built as a multi-lane roundabout, within 12 months after opening, over 120 crashes occurred. An evaluation was made, and volumes were not as high as originally planned. Lanes were then changed (to right-turn lanes, or eliminated) so that only single through lanes were provided, along with some minor alignment changes. Other roundabouts have had minor adjustments (for instance, outside curbs installed instead of shoulders to reduce rutting.)
Q: Striping and signing modifications have been made to the multi-lane roundabout near Astoria at the intersction of US 101/OR 202 to improve sight lines and driver behavior.
R: US 50/US 15 intersection (Gilbert's Corner) in Loudoun County
S: SR 510/Pacific Avenue intersection was striped to reduce capacity; SR 16 Southbound Ramp/Borgen Blvd intersection was restriped and the capacity reduced to correct a design flaw involving back to back double left movements
T: The lane configuration was adjusted on one approach at the roundabout at the intersection of WV 705/US 119 in Morgantown
U: Broadway Street (STH 32/57) roundabout in De Pere was modified to accommodate dual northbound left-turns and lower volume eastbound through and left movements
V: Paved the inner circle to allow Oversize/Overweight loads to navigate the intersection on a hard surface

State	Guidance on the accommodation of large vehicles (trucks, emergency vehicles, farming equipment, oversize/overweight vehicles, etc...) at roundabouts?	
	Has your state developed guidance on the accommodation of large vehicles (trucks, emergency vehicles, farming equipment, oversize/overweight vehicles, etc...) at roundabouts?	*Yes, please provide the document name where we can find the information:Is the design-vehicle accommodation guidance provided in the material uploaded in question 19?*
Alaska	Yes	
Arkansas	No	
California	Yes	A
Connecticut	No	
Delaware	Yes	
Florida	No	
Georgia	Yes	B
Idaho		
Illinois		
Indiana	Yes	C
Iowa	Yes	D
Kansas	Yes	E
Kentucky	Yes	F
Louisiana	Yes	
Maine	No	
Maryland	No	
Massachusetts	No	
Michigan	No	
Minnesota	Yes	G
Mississippi	No	
Missouri	Yes	H
Montana	No	
Nebraska	Yes	
Nevada	No	
New Hampshire	No	
New Mexico	No	
New York	Yes	I
North Carolina	No	
North Dakota	No	
Oregon	Yes	J
Pennsylvania	No	
Rhode Island	No	
South Dakota	Yes	K
Texas	No	
Vermont	No	
Virginia	Yes	L
Washington	Yes	M
West Virginia	No	
Wisconsin	Yes	N
Wyoming	Yes	

A: California Highway Design Manual, Chapter 400
B: Information included in Chapter 8 of the Georgia DOT Design Policy Manual (http://www.dot.ga.gov/PartnerSmart/DesignManuals/DesignPolicy/GDOT-DPM.pdf)
C: Indiana DOT - 2013 Design Manual, page 115 (http://www.in.gov/indot/design_manual/files/Ch51_2013.pdf)
D: Iowa DOT Design Manual, Chapter 6, Section 6A-3 (http://www.iowadot.gov/design/dmanual/06a-03.pdf)
E: Kansas Roundabout Guide - 2nd Edition (https://www.ksdot.org/burtrafficeng/roundabouts/roundabout_guide/roundaboutguide.asp
F: Kentucky Transportation Cabinet Design Guidance, page 6&7 (http://transportation.ky.gov/Highway-Design/Memos/Design%2003-10.pdf)
G: Minnesota DOT Road Design Manual Chpter 12 - Guidelines for Modern Roundabouts (http://dotapp7.dot.state.mn.us/edms/download?docId=1062365)
H: Accommodating Small and Large Users at Roundabouts (http://www.ghd.com/pdf/roundabouts-TAC2009-Small-and-Large-Users-at-Roundabouts.pdf)
I: Draft Highway Design Manual 26.4.5 tells designers to determine appropriate design vehicle. If Oversize/Overweight, designers will need to contact Main Office for assistance
J: Oregon DOT Roundabout Directive DES-02 (http://www.oregon.gov/ODOT/HWY/TECHSERV/docs/pdf/des_02.pdf); soon in the ODOT Highway Design Manual, Chapter 8
K: South Dakota DOT typically designs for the WB-67, however, they have designed roundabouts to accommodate longer combination vehicles (LCVs). See page 12-15 (http://sddot.com/business/design/docs/rd/rdmch12.pdf)
L: WB-67 vehicle
M: Washington DOT Design Manual, Chapter 1320 (http://www.wsdot.wa.gov/publications/manuals/fulltext/M22-01/1320.pdf)
N: Wisconsin DOT Facilities Development Manual, Chapter 11, Section 26, Sections 10.2 & 30.5.4 to 30.5.7 (http://wisconsindot.gov/rdwy/fdm/fd-11-26.pdf#fd11-26)

State	Illumination standard/guidance						
	Does your state follow developed standards/guidance on the illumination of roundabouts?	*What is the basis for your state's illumination standard/guidance?*					
		AASHTO Roadway Lighting Design Guide	*IES Design Guide for Roundabout Lighting*	*NCHRP Report 672*	*State-specific standard*	*Other*	*Other, please specify*
Alaska	Yes	X	X	X		X	A
Arkansas	Yes	X	X	X			
California	Yes				X		B
Connecticut	Yes	X		X			
Delaware	Yes						
Florida	Yes			X	X		
Georgia	Yes	X	X	X	X	X	C
Idaho							
Illinois							
Indiana	Yes	X		X			D
Iowa	No						
Kansas	Yes					X	E
Kentucky	Yes	X					
Louisiana	Yes		X				F
Maine	No						
Maryland	Yes		X				
Massachusetts	Yes		X	X			
Michigan	Yes			X			
Minnesota	Yes	X	X			X	G
Mississippi	Yes	X		X			
Missouri	Yes				X	X	H
Montana	Yes	X		X			
Nebraska							
Nevada	Yes	X	X	X			
New Hampshire	Yes	X					
New Mexico	Yes	X	X	X			
New York	Yes		X	X		X	I
North Carolina	Yes	X					J
North Dakota	Yes	X					
Oregon	Yes	X					
Pennsylvania	Yes	X		X			
Rhode Island	No						
South Dakota	Yes	X					K
Texas	Yes	X				X	L
Vermont	Yes				X		
Virginia	Yes			X			
Washington	Yes					X	M
West Virginia	Yes	X		X			
Wisconsin	Yes	X			X		
Wyoming	Yes		X				

A: AASHTO's "An Informational Guide for Roadway Lighting" 1984
B: California Highway Design Manual, Chapter 400
C: Chapter 8 of the Georgia DOT Design Policy Manual (http://www.dot.ga.gov/PartnerSmart/DesignManuals/DesignPolicy/GDOT-DPM.pdf)
D: Indiana DOT - 2013 Design Manual, page 134 (http://www.in.gov/indot/design_manual/files/Ch51_2013.pdf)
E: Kansas Roundabout Guide - 2nd Edition (https://www.ksdot.org/burtrafficeng/roundabouts/roundabout_guide/roundaboutguide.asp
F: Louisiana DOT uses the IES Design Guide for Roundabout Lighting. They do not require roundabouts to be lit.
G: Roundabouts: An Informational Guide 1st Edition; Roadway Lighting Design Manual (http://www.dot.state.mn.us/trafficeng/lighting/2010_Roadway%20Lighting_Design_Manual2.pdf)
H: http://epg.modot.mo.gov/index.php?title=Category:901_Lighting
I: Draft Highway Design Manual 26.6.2.
J: The Roadway Lighting gropu uses AASHTO Roadway Lighting Design Guide solely in roundabout lighting design in TIP projects and in roundabout lighting design encroachments review. For roundabouts located in continuously illuminated roadways, the roundabout should be lit to a level that is 2 the value used on the best lit approach. This design light level is in general agreement with NCHRP 672. For roundabouts with unlit connecting roadways, the roundabout should be lit to a level that is 1.3 times the value of the connecting roadway with highest roadway classification.
K: South Dakota DOT Road Design Manual, Chapter 12, page 15-29 (http://sddot.com/business/design/docs/rd/rdmch12.pdf)
L: ANSI RP-8-00
M: Washington DOT Design Manual, Chapter 1320 (http://www.wsdot.wa.gov/publications/manuals/fulltext/M22-01/1320.pdf)
N: Wisconsin DOT Facilities Development Manual, Chapter 11, Section 11, (http://wisconsindot.gov/rdwy/fdm/fd-11-26.pdf#fd11-26)

State	What are the major reasons why your agency has not built roundabouts on the state system?							
	They are not part of design standards used by our agency	*Not sure they work efficiently*	*Not sure they are safe*	*Not sure that the drivers will get used to them*	*Concerned about liability issues*	*Other*	*Other, please explain*	*Is your agency considering the construction of roundabouts?*
Alaska								
Arkansas								
California								
Connecticut								
Delaware								
Florida								
Georgia								
Idaho	X					X	A	Yes
Illinois								
Indiana								
Iowa								
Kansas								
Kentucky								
Louisiana								
Maine								
Maryland								
Massachusetts								
Michigan								
Minnesota								
Mississippi								
Missouri								
Montana								
Nebraska								
Nevada								
New Hampshire								
New Mexico								
New York								
North Carolina								
North Dakota								
Oregon								
Pennsylvania								
Rhode Island								
South Dakota								
Texas								
Vermont								
Virginia								
Washington								
West Virginia								
Wisconsin								
Wyoming								

A: Tradition

APPENDIX D

Case Examples

California (Caltrans)

Roundabout Selection

- Caltrans uses an Intersection Control Evaluation (ICE) policy for selecting intersection control
- The Caltrans ICE policy was published in 2013 and applies to all project types on intersections and interchanges on the State Highway System.
- The motivation for the ICE policy was originally systematic implementation of roundabouts and was expanded to refer to other intersection types.
- For the past 7 or 8 years the Caltrans Safety Management Program was promoting roundabouts as a countermeasure.
- Most (approximately 95%) of roundabouts on the ground in California are a result of local agency desire, action and funding, and occurred before the ICE was put in place.

Modifications to Existing Roundabouts

- One state highway roundabout was originally constructed as a partial multilane roundabout was converted to a single-lane roundabout.
- In Long Beach, a redesign of a multilane roundabout/traffic circle hybrid is planned to reduce capacity but not reduce the diameter of the existing circle. The project will reduce the width of the roundabout approaches and circulatory roadway, and was motivated by a high number of property damage only crashes. While the modifications will increase vehicle delay, the expectation is to see a reduction in the number of crashes.

Design Vehicle

- The design vehicle is dictated by the Surface Transportation Assistance Act (STAA).
- The design vehicle depends on which "network" the intersection or interchange is on, and the classification of the road.
- Four STAA vehicle types are: STAA 53, STAA 48, STAA Double, STAA ELLN (Extralegal Load).
- This varies slightly from other state DOT nomenclature but the vehicles are similar sizes.
- The design vehicle accommodation is customized based on intersection traffic conditions.
- Some effort to accommodate extra sized loads.
- Three roundabout rodeos have been conducted, and all were highly successful.

Accelerated, Low-Cost Roundabouts

- Caltrans is open to the learning more about opportunities but it seems to be something that may be more interesting to municipalities.
- Los Angeles completed an overnight implementation of a roundabout.
- City of Modesto implemented a temporary roundabout over the course of a few days using channelizers and markings that has been in service for seven years.

Implementation and Effectiveness of Policies

- Since the ICE policy went into effect there has been a dramatic change in the number of roundabout alternatives being evaluated and selected, and a reduction in the time to determine if the roundabout is a viable alternative.
- The policy requires the consideration of roundabouts, which was inconsistent and infrequent prior to ICE.
- There are no examples of ICE where the optimum outcome was not a roundabout.
- In the ICE process, a well-conceived roundabout alternative is very competitive.

Quality Control

- Review process within Caltrans is not formal.
- Case-by-case review.
- Help municipalities access the technical assistance through FHWA.
- Relying on consultant reviews through an informal process.
- Caltrans encouraging project managers to utilize peer review in the design contracts for more complex locations.

Connecticut (ConnDOT)

Roundabout Selection

- Most roundabout proposals are coming from municipalities but ConnDOT also proposes them.
- The request from municipality is usually made by the town engineer or public works director but just was just recently approached by a town planner.
- Most exposure to roundabouts in Connecticut came through word of mouth or engineering publications.
- Connecticut differs from other states because there is no county government, and the two major stakeholders are the state and the municipality.
- If there is strong support from the town it makes the process go quicker.
- Initial installation faced strong opposition; there were 300+ people at the public hearing, but strong political support to deliver the project. In the end, crashes were reduced and congestion went away, accomplishing the major goals of the project.
- ConnDOT is focused on installing roundabouts where they can be successful.

Phased Implementation Approach

- ConnDOT is interested in a phased approach, but have not done so yet.
- The last roundabout that was built was designed for 20 years out and it was built with excess capacity. ConnDOT has seen that the roundabout could have been opened up as a single-lane roundabout.
- ConnDOT has six multilane roundabouts and three could open as single lane roundabouts for the first ten years,

eliminating the ability for drivers to cross over lanes and taking the fastest path through the roundabout.
- ConnDOT is starting to question the traffic volume projections, and instead making the roundabout work for ten years.

Modifications to Existing Roundabouts

- ConnDOT has not modified any roundabouts in Connecticut.
- ConnDOT has modified older rotaries.
- First rotary modification was in was in Killingworth, Connecticut.
- There was no deflection so ConnDOT installed a truck apron to improve safety.
- ConnDOT received a National Roadway Safety award from FHWA for the Killingworth rotary modification.
- A rotary in Seymour, Connecticut is being modified now for less than $700,000 as opposed to $2,000,000 for a new roundabout.
- Because of the reduced cost the Seymour project is getting a lot of support.

Design Vehicle

- WB-50 used to be the default design vehicle, but now a WB-62 or WB-67 is most commonly used.
- WB 62 for most of the movements in the intersection and WB-67 for landscaping.
- Low clearance truck trailers (lowboys) have been challenging.
- For lowboy accommodation ConnDOT keeps the same cross-slope for the circulatory roadway and truck apron.
- One roundabout has an 11% slope on the approach to the roundabout and there have been no issues with plowing.
- Splitter islands have a hole cast for installing a rod in the winter, which serves as a warning device to the alert the plow driver to the location of the splitter island.
- The center island truck apron must be at least as wide as the snow plow wheel base width.
- One concrete truck apron was chipped by a plow so ConnDOT now uses a granite curb detail with a chamfer.

Accelerated, Low-Cost Roundabouts

- Because of rotary retrofits, this is not as applicable.
- Some towns are trying minis. In one case the center island was developed using only paint that hasn't been as effective. There could be some challenges with implementing Mini roundabouts in in Connecticut.
- ConnDOT is putting extra emphasis on making sure fastest paths are checked at mini-roundabouts.

Implementation and Effectiveness of Policies

- ConnDOT was initially focused first on single-lane roundabouts but is now branching out toward multilane roundabouts.
- The highway design manual is currently being rewritten and will have additional guidance on roundabouts.
- ConnDOT is interested in putting in language specifying a preference for roundabouts.
- ConnDOT is not able to influence consultant design.
- Consultants and municipalities now propose roundabouts which is a change from a few years ago.

Knowledge Gaps

- ConnDOT's implementation strategy is working out well.
- On the technical side ConnDOT is learning as they get more experience. For instance, ConnDOT is now using granite on the truck apron.
- ConnDOT has expanded some of the information regarding roundabout design, but they mostly point to *NCHRP Report 672* for details.

Quality Control

- All the roundabouts built in Connecticut have gone through in-house design at ConnDOT.
- ConnDOT has spent a lot of time observing post construction.
- So far there has been a small pool of designers able to design roundabouts, but the pool of designers is growing.
- ConnDOT has identified additional details needed in the highway design manual.
- ConnDOT used an external reviewed for the first proposed roundabout in the state.

Other

- ConnDOT is interested in seeing how phased implementation works.
- A roundabout proposed in Manchester, Connecticut will have rail going right through the middle of the intersection.
- There are potentially 20 to 25 planned roundabouts on state roads.
- The roundabouts that have been built, work!

Georgia (GDOT)

Roundabout Selection

- The majority of roundabouts are identified through the safety program.
- Many in design or construction have been identified by particular needs in the field, for example difficult intersection geometry or crash pattern.
- 1999 was the first roundabout in Georgia. A draft policy was developed in 2001 that was formally adopted in 2004.
- In 2008 the language changed from encourage to "preferred" and allowed multilane roundabouts.
- GDOT is now getting local municipalities asking for roundabouts.
- The policy requires consideration of a roundabout during signal permit or any other type of project, which has triggered a lot of proposed roundabouts.

Phased Implementation Approach

- If traffic volumes in the future-year analysis warrant a multilane roundabout GDOT recommends a phased approach.
- Most have been built with the outside footprint, circle, and splitter island geometry of the ultimate multilane roundabout.
- One roundabout was supposed to be phased but GDOT ended up building the full multilane roundabout due to an uptick in volumes prior to construction.
- Most projects use a 20 year design horizon to meet federal requirements.

- GDOT uses a ten year window for considering a phased approach.
- GDOT prefers opening roundabouts as a single-lane roundabout. If the roundabout will operate acceptably as a single-lane roundabout for at least seven to ten years, GDOT will open as a single-lane roundabout.

Modifications to Existing Roundabouts

- So far GDOT has only modified roundabouts in the design process. Because of the restriction on building multilane roundabouts lifted in 2008, GDOT doesn't have a lot of multilane roundabouts to modify.

Design Vehicle

- The design vehicle for roundabouts in Georgia is WB-67 truck.
- GDOT has aided municipalities with roundabouts not on the state highway system.
- In cases where a smaller design vehicle was used, GDOT encouraged hardscape on the center island.
- Depending on the routes GDOT can design for oversize-overweight (OSOW) vehicles, with a focus on over-length vehicles.
- GDOT knows the over-length vehicle routes but not the vehicle axle spacing. GDOT is now requiring the axle spacing to be able to model potential truck turning movements.
- The GDOT OSOW office tracks the over-length history and determines, based on the routes, if there is a need to accommodate OSOW vehicles, otherwise GDOT looks to use parallel routes.
- One example is a Kia plant being built; once the factory is done there is no longer a need to accommodate over-length vehicles.
- GDOT does not design to accommodate side by side truck movements, nor does GDOT design to allow full straddling.
- GDOT designs to allow a truck in the right lane to over-track but still leave room for a car in the adjacent lane.

Accelerated, Low-Cost Roundabouts

- In District 1 GDOT used state forces to install a mini roundabout. Modular curbing was used to define the center island and was backfilled with asphalt.
- If GDOT was to repeat the installation, GDOT would have used a more rigid curbing system.
- Project included widening on three of the four corners and a 90 foot inscribed circle diameter roundabout.
- The cost was $63,000 including full repaving and striping.
- GDOT has conducted two or three "quick response" projects that have $200k budget cap.
- GDOT used district maintenance resources and a general contractor.
- Contractor built central island and set the intersection grades and then GDOT did asphalt overlay on all approaches.
- Challenges were coordination between forces, and actual costs may have been higher, overall costs were probably closer to $300K.
- Another location is more temporary, using just rigid modular curb for the roundabout layout, and no paving.
- GDOT is procuring rigid modular curb, as most locations are on roadways that do not have curb and gutter.
- This practice has been effective at reducing queues and crashes.

Implementation and Effectiveness of Policies

- The policy reads as a "shall" condition, but there is some room to get around the policy.
- The policy could be stronger and require a clearer statement of why the roundabout was not chosen.
- An ICE policy would help.

Knowledge Gaps

- There is not a lot of flexibility in available roundabout design guidance.
- With a decent design and good speed control, roundabouts have proven safety and operational benefits.
- Without ICE, GDOT engineers have to convince the GDOT project manager and highway design folks to get a roundabout to the concept level. Otherwise, a signal will be installed with the safety benefits of a roundabout ignored.
- Some consultant peer reviews have made it difficult to implement due to increased costs due to consultant comments.
- GDOT would like know what design requirements could be relaxed (curb and gutter or illumination, for instance) to increase the cost-effectiveness.

Quality Control

- GDOT does a peer review on most roundabouts.

Public Rights-of-Way Accessibility Guidelines (PROWAG)

- We provide conduit under the road where the signal would go. Just the piece of conduit.

Kansas (KDOT)

Roundabout Selection

- Roundabout selection has been strictly based on crashes, but operations are considered.
- Requests from municipalities for gateway treatments are fairly frequent.
- From a local perspective, cities have used roundabouts as a traffic calming device in locations with less frequent and less severe crashes.
- Many roundabout locations are off of the highway system. Kansas has a reputation for roundabouts partially because of many local examples.
- Lawrence, Kansas, has a roundabouts first policy because of the positive impacts of roundabouts.

Phased Implementation Approach

- For a phased approach KDOT builds the outside geometry and allows for expansion to the inside.

- Partially because of recent experience with a multilane roundabout in Emporia, Kansas, multilane roundabouts are not viewed as favorable at the moment.

Modifications to Existing Roundabouts

- A multilane roundabout in Emporia, Kansas was reconfigured to a single lane roundabout. A number of trucks were over turning, and confusion with navigation was identified as issues. Since the capacity was reduced, there haven't been further problems (converted 18 months ago).
- Agency has shifted focus to be supportive of the community's desires.

Design Vehicle

- The design vehicle for roundabouts matches the design vehicle for the highway network in which the roundabout exists.
- Most roundabout designers are well aware of oversize/overweight vehicle concerns as it is mentioned throughout the KDOT roundabout design guide.
- There is no standard super-load vehicle.
- WB-67 was the design vehicle in Lyndon, Kansas, but KDOT tweaked the design to allow rear-steer for larger loads, and to broaden the range of roundabouts.
- Wind energy has loads that are big and bulky but not heavy. These vehicles must obtain a permit for transport of the 130–150 foot loads.

Accelerated, Low-Cost Roundabouts

- KDOT is not doing this, but there might be some local examples within Kansas.

Knowledge Gaps

- KDOT used shoulders on a couple roundabouts, but believes curbing provides positive guidance for drivers.
- Most roundabouts are concrete pavement, and KDOT would like more information on the best ways to stage reconstruction of concrete roundabouts.
- Experience in Emporia reinforced a phased approach.
- OSOW and wind energy vehicle accommodation are the two biggest design needs at the moment.

Other

- KDOT hears from other states that the KDOT guide is being used for their design guidance.
- KDOT is still building dumbbell roundabouts because they are better with speed control than ovals and the cost of bridges is less.

Maryland

Roundabout Selection

- Roundabouts have become the default intersection form in Maryland.
- Roundabouts are mostly proposed for safety reason, but a few are capacity driven, and one in Mount Rainier, Maryland, was economic driven.
- Consultants working on development projects know SHA is going to require the evaluation of a roundabout, so they're proposing them as part of development project as well.
- Maryland has had their policy requiring evaluation for a while now. The policy is strictly enforced which has led to roundabouts becoming the default intersection choice.

Phased Implementation Approach

- The Towson Circle and I-495/Ritchie-Marlboro Road interchange ramp terminal roundabouts were all built as two-lane multilane roundabouts, but planned to be expanded to three-lanes. Towson Circle was reduced to a hybrid single-lane/multilane roundabout a few years ago, and will never be expanded, and the Ritchie-Marlboro Road roundabouts were expanded to three lanes due to development pressure.
- Because of SHA's experience with modifying many of the early multilane roundabouts, SHA attempts to open a roundabout as small as possible.
- If a roundabout will get at least five to ten years of service with a smaller configuration, SHA will open the roundabout smaller.

Modifications to Existing Roundabouts

- The Towson Circle was reduced from a two-lane multilane roundabout to a hybrid single-lane/multilane roundabout.
- The roundabout at an interchange ramp terminal in Arundel Mills, Maryland was removed to allow a diverging diamond interchange to be constructed.
- Roundabouts near Fort Meade and in Odenton were both modified by reducing capacity.

Design Vehicle

- SHA uses a WB-67 design vehicle as the default for all state routes.
- Many of the early roundabouts used a WB-50 design vehicle. While WB-67s can get through these roundabouts, markings around the intersections indicate they are not doing so without off-tracking on curbs or outside shoulders. (Although outside shoulders were used at many of Maryland's early roundabouts, Maryland uses curb and gutter for all new roundabouts, and roundabout retrofit projects).

Accelerated, Low-Cost Roundabouts

- SHA built a mini-roundabout using thermoplastic and tape at the intersection of US 50/Thompson Creek Road in Stevensville, Maryland.
- The roundabout cost about $50 thousand, and has been in place for five to ten years.
- SHA hasn't made a habit out of building more low-cost roundabouts, and credits the successful implementation of the roundabout in Stevensville to a low-speed environment, and an intersection without any real through movements.

Knowledge Gaps

- Maryland acknowledges some early mistakes made in regards to roundabout design.

- In particular, Maryland did not understand the potential for path overlap at multilane roundabouts, and has attempted to restripe or reduce the number of entering lanes to correct the issue.

Roundabout Cost

- All roundabouts in Maryland now have curb and gutter and illumination. This wasn't the case at many early roundabouts.
- In particular, maintenance of traffic is driving up the project cost at many roundabouts.

Quality Control

- All roundabout designs are reviewed to ensure compliance with design guidelines (*NCHRP Report 672*).

Public Rights-of-Way Accessibility Guidelines (PROWAG)

- Maryland is attempting to "do the right thing" and at a minimum installing conduit at all multilane crossings.

Minnesota (MnDOT)

Roundabout Selection

- MnDOT uses an ICE process at every intersection project. An ICE process has been used for six years in Minnesota.
- The intersection control is not pre-determined; the ICE process drives the selection. However, sometimes there are other reasons that drive the selection process, primarily safety.
- The process previously only had a signal warrant report but was later broadened to include roundabouts.

Modifications to Existing Roundabouts

- Two roundabouts were modified from their original design. They were built using a 20-year traffic forecast for the design and a multi-lane roundabout was needed to accommodate the projected traffic. One location had performance issue immediately, the other had issues over the course of a few years. The traffic volumes at both locations were low enough that a single lane could have worked acceptably. One location was converted to a single-lane roundabout with striping and signing. At the other location, curbs were on two quadrants.
- There have been a few other instances of striping and signing changes.
- MnDOT is now considering more closely if a roundabout only marginally meets the threshold for multiple lanes, if so then MnDOT builds a single lane roundabout.

Design Vehicle

- Design vehicle type varies based on the type of roadway facility. The design vehicle for trunk highways is a WB-62 truck and a low clearance trailer (lowboy).
- MnDOT verifies that the sign placement doesn't fall within the path of the vehicles.
- MnDOT is rethinking the truck apron height, for now, it is still four inches.

Accelerated, Low-Cost Roundabouts

- No implementations from MnDOT so far, but in Minneapolis modular curbing was used for a temporary installation.

Implementation and Effectiveness of Policies

- Per the engineering community, existing policies are pretty solid. The engineering community has not had any problems with implementing the policies from an engineering and technical point of view.
- One challenge is when a community wants a roundabout and a four way stop or traffic signal is proposed. There can be a lot of political will for a roundabout, but a four way stop may be practical and is a fraction of the cost.

Knowledge Gaps

- How does MnDOT better design the roundabout for the opening year? How does MnDOT design something that works when it is opened and can be easily converted to accommodate future year volumes?
- A few instances where a signal was implemented 15 years ago and a roundabout is being considered. There are property damage only (PDO) crashes but how can we capture the existing value of the asset?

Quality Control

- Most proposed roundabouts go through a roundabout review team made up of persons involved with designs. They make sure it is a sound design and this functions as a quality control check.

Washington (WSDOT)

Roundabout Selection

- Most roundabouts are brought forward because of local or DOT preference for roundabouts.
- Chapter 13 Intersection "type" requires why a designer chose the intersection type: life cycle, mobility, and safety. Section 1300 is the policy, chapter 1320 is the roundabout design chapter. These both provide a lot of flexibility.
- Seeing the obvious benefits; WSDOT needed to legitimize the roundabout as an alternative, so the process was formalized. It was developed at the project traffic and operations sections.
- Roundabouts continued to be implemented because WSDOT had the right folks weighing in on the process. WSDOT learned that it was important to implement roundabouts when opportunities presented themselves.

Modifications to Existing Roundabouts

- WSDOT has taken capacity out of multiplane roundabouts to minimize minor crash history: most are entering vehicles not yielding to circulating vehicles. These crashes are

typically property damage only (PDO) and modification involved reducing entry capacity. This was done at two locations.
- WSDOT rebuilt roundabouts at an interchange that was built in the late 1990s. Reconstruction included re-striping and semi-permanent curb. These locations had mostly PDO crashes.
- Not many modifications compared to the 105 WSDOT roundabouts that have been constructed.
- A roundabout was located on a bridge collapse detour route, and handled thru and left turns.

Design Vehicle

- WSDOT first looks at the facility type, and then drills down to the individual movements within the intersection.
- WSDOT allows straddling of lanes as permitted by state law in its original form.
- With advent of practical design a WB-67 is not always needed, instead WSDOT looks at the individual movements.
- WSDOT recently modified the detail for the truck apron height from three inches to two inches.
- WSDOT engages region operations and traffic personnel. Section 1329 of the WSDOT design guidance references vehicle accommodations.

Accelerated, Low-Cost Roundabouts

- WSDOT has done this at four locations, and all involved interim fixes in a weekend.
- These are typically done at compact roundabouts.
- No policy regarding this application but the traffic section has embraced them.
- They have been used at interchanges that are backing up on to the mainline. Local agencies are picking up on the idea as well.
- Primarily striping and signing, and the cost have been about $200,000 to $300,000 for the three county owned intersections.
  – These are good examples of interagency coordination.

Implementation and Effectiveness of Policies

- In the near term WSDOT has been focused on the implementation of roundabouts. Despite other successful projects, there is still resistance.
- Moving ahead, WSDOT is looking at life-cycle costs, especially considering that signals require ongoing maintenance and retiming.

Knowledge Gaps

- Knowledge gaps within WSDOT exist between Planning and Design.
- Design plans that are on the shelf are outdated in a year.
- Understanding that nodes are more important than the links.
- Speed is the not the defining factor of mobility.
- Access management could play a stronger role in transportation planning.

Quality Control

- All projects have a regional level review supported with headquarters supplied expertise.

Public Rights-of-Way Accessibility Guidelines (PROWAG)

- WSDOT is working to make sure there is an active warning system at multi-lane crossings.

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FAST	Fixing America's Surface Transportation Act (2015)
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TDC	Transit Development Corporation
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation

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