Improving Driver's Ability to Safely and Effectively Use Roundabouts: Educating the Public to Negotiate Roundabouts

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16. Abstract

This report documents the results of a study aimed at developing materials to educate the public on the appropriate use of roundabouts. The study began with the identification of roundabouts throughout the State of Michigan. This was followed by an investigation of those factors affecting operations and safety at roundabouts in the State of Michigan, as well as a determination of public perceptions as they relate to roundabouts. This investigation included a comprehensive state-of-the-art literature review, national and statewide state-of-the-practice surveys, an evaluation of statewide roundabout crash data, a series of field behavioral studies at several roundabout locations, and the implementation of a statewide road user survey. Based upon the results of this investigation, a suite of materials were created, which included tri-fold brochures, posters, PowerPoint slides, animations, and videos. These materials provide a diverse toolbox for use by MDOT and other Michigan road agencies to educate the public as to safe and correct use of roundabouts, as well as the benefits associated with roundabouts in comparison to traditional intersections. Ultimately, it is expected that the public awareness materials that were developed as a part of this project will serve to enhance the ability of MDOT and other state agencies to improve road user's understanding and abilities to successfully use roundabouts throughout the State of Michigan.

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TABLE OF CONTENTS **PAGE**

LIST OF TABLES **PAGE**

LIST OF FIGURES **PAGE**

1.0 INTRODUCTION AND BACKGROUND

The modern roundabout is a circular intersection that requires vehicles to travel counterclockwise around a center island. Roundabouts generally provide several advantages in comparison to signalized intersections as they: (1) eliminate the conflict points that contribute to head-on, head-on left-turn, and angle collisions; (2) force vehicles to slow down; and (3) reduce the number of stops by vehicles, thereby decreasing emissions and improving fuel economy. In contrast to earlier traffic circles where priority was given to entering vehicles, roundabouts follow a "yield-at-entry" rule, requiring entering vehicles to wait for a gap in circulating traffic before entering the roundabout. Both within the center circle and at the exits, slow speeds are maintained by the deflection of traffic around the center island and the smaller radii at the entrance and exit approaches.

Collectively, these factors generally provide for improved traffic operations and safety in comparison to traditional intersections [*1*]. While these benefits, particularly those related to safety have been documented by numerous international studies, the lack of evidence regarding the performance of roundabouts in the United States may have been one factor contributing to the slow integration of roundabouts into design practice at the national level. Jacquemart [*2*] found that 80 percent of responding state agencies had not built any roundabouts at the time of a 1997 survey. The primary reasons these states had not constructed any were concerns over whether drivers would be able to get used to them (37.1 percent), whether they worked efficiently (34.3 percent), and whether they were safe (17.1 percent).

Flannery and Datta [*3*] conducted the first domestic safety evaluations of roundabouts, examining six retrofitted sites that exhibited crash reductions from 60 to 70 percent at five of the six locations. Flannery and Elefteriadou [*4*] conducted a before-and-after study of eight single lane roundabouts shortly after installation and found both the frequency and rate of total crashes and injury crashes to have decreased. Persaud et al. [*5*] conducted a more thorough study of 23 intersections that were converted from traditional stop and signal-controlled intersections to roundabouts. The resulting Empirical Bayes analysis showed a 40 percent reduction in total

crashes and an 80 percent reduction in injury crashes. The research literature includes various other examples of positive safety evaluations including *NCHRP Report 572*, which examined data from 55 roundabouts as a part of a before-and-after study. The results showed that for single-lane roundabouts converted from stop control, total crash reductions were between 58 and 72 percent and injury crashes were reduced by 82 to 88 percent [*1*].

In addition to these safety benefits, roundabouts have also been shown to reduce vehicle delays by about 75 percent in comparison to previous intersection configurations [*1*]. Collectively, these documented benefits have led to a rapid increase in the construction of roundabouts in recent years. As a part of a 2003 effort, Rodegerdts et al. [*1*] identified 310 roundabouts from across the United States and Kittelson and Associates currently maintain a database, which includes information regarding more than 1,100 roundabouts [*6*]. Though the precise number is uncertain, current estimates indicate that there are at least 2,300 roundabouts in the United States today [*7*].

While the consensus among researchers is that roundabouts generally create significant safety and operational benefits in comparison to signalized and stop-controlled intersections, their acceptance by the general public is frequently a concern of transportation agencies as past research has demonstrated strong public sentiment against roundabouts [*8, 9, 10*]. The reasons for these public concerns vary, as do the legitimacy of some of the concerns. While the first modern roundabout in the country was installed in 1990 and the first Michigan roundabout was constructed in 1996, they are still a relative novelty. Consequently, a substantial number of road users are still unfamiliar with how to appropriately negotiate roundabouts. This lack of familiarity has several drawbacks, one of which is frequent public opposition during the planning stage from local residents and elected officials who question their effectiveness [*11*]. From a public standpoint, the major problem with this unfamiliarity is that many drivers are unsure of how to drive through a roundabout appropriately, which can lead to a temporary increase in crashes. For example, following reconstruction of a traffic circle to a multilane roundabout at Michigan State University in 2000, the annual number of crashes increased from 17 to 37 [*12*]. Though crashes still occur at roundabouts, they generally tend to be less severe as the most prevalent types of crashes are rear-end and sideswipe collisions [*13*]. Many of these crashes

occur near the roundabout entrances where drivers may be uncertain of the right-of-way laws for entry and exit from the circulating roadway. This lack of knowledge is most problematic during the time immediately after the roundabout is open to traffic when higher levels of driver confusion are exhibited due to unfamiliarity, particularly in areas where roundabouts had not existed before [*13*].

Lack of knowledge about relevant traffic rules has also been shown to pose challenges [*14*]. Ambiguity as to the rules of the road in roundabouts affects both bicyclists and pedestrians. Since oncoming vehicular traffic approaches only from the left side, drivers must train themselves to scan in the other direction to identify pedestrians. In spite of these facts, a recent evaluation of pedestrian and bicyclist behaviors did not reveal any substantial safety problems for non-motorists based on traffic conflict and crash studies [*15*].

Roundabouts may also present issues specific to particular segments of the driving population. For example, older drivers may lack comfort and confidence when navigating roundabouts and their unfamiliarity and reduced physical skills can make navigating roundabouts a challenging task. A recent study [*16*] suggests design elements that improve path guidance for older drivers can help to encourage roundabout use within this age group. McKnight et al. [*17*] found that older drivers, females, and drivers who admitted to not wearing seatbelts had a propensity to incorrectly negotiate roundabouts. Conversely, some groups of drivers have proven more capable of adapting to roundabouts, including those who had driven through them before, those who drove specialty vehicles (e.g., bus, police car, fire truck), younger drivers, and male drivers [*17*]. From a transportation agency standpoint, it is imperative that all drivers are equipped with sufficient knowledge, skills, and abilities in order to safely and efficiently use roundabouts.

2.0 PROBLEM STATEMENT AND STUDY OBJECTIVES

The primary goal of this research was to develop a series of educational materials that can be utilized by MDOT to educate the traveling public as to the appropriate use of roundabouts and the benefits of roundabouts in comparison to signalized intersections. These educational

materials provide tools for use in public meetings and through other forms of delivery media. The specific objectives of this study were as follows:

1. Investigate driver behavior and characteristics as they relate to navigating a roundabout.
2. Investigate crash data at roundabouts to develop a typology of crashes.
3. Determine the public's perception and understanding of roundabouts.
4. Create a model to educate the public on how to make safe and effective use of roundabouts.

3.0 STUDY METHODOLOGY

To accomplish these objectives, the methodology illustrated in Figure 1 was developed as a part of this research. This study began with a review of research on roundabouts, specifically in regard to the public perception of traffic operations and safety at roundabouts, as well as the use of educational programs aimed at improving road user knowledge. As a part of the literature review process, roundabouts throughout the State of Michigan were identified in coordination with MDOT. Road user behaviors at Michigan roundabouts were evaluated using Michigan State Police crash data and behavioral data collected through a series of field studies at a sample of locations. A questionnaire survey was also conducted to obtain public feedback on their comfort level and knowledge regarding roundabouts. Based upon the problem areas and concerns identified, a series of themes were identified that were subsequently addressed through the development of educational materials. These programs were developed in coordination with MDOT to provide an effective means of improving public perception and mitigating public concerns about roundabout operations and safety.

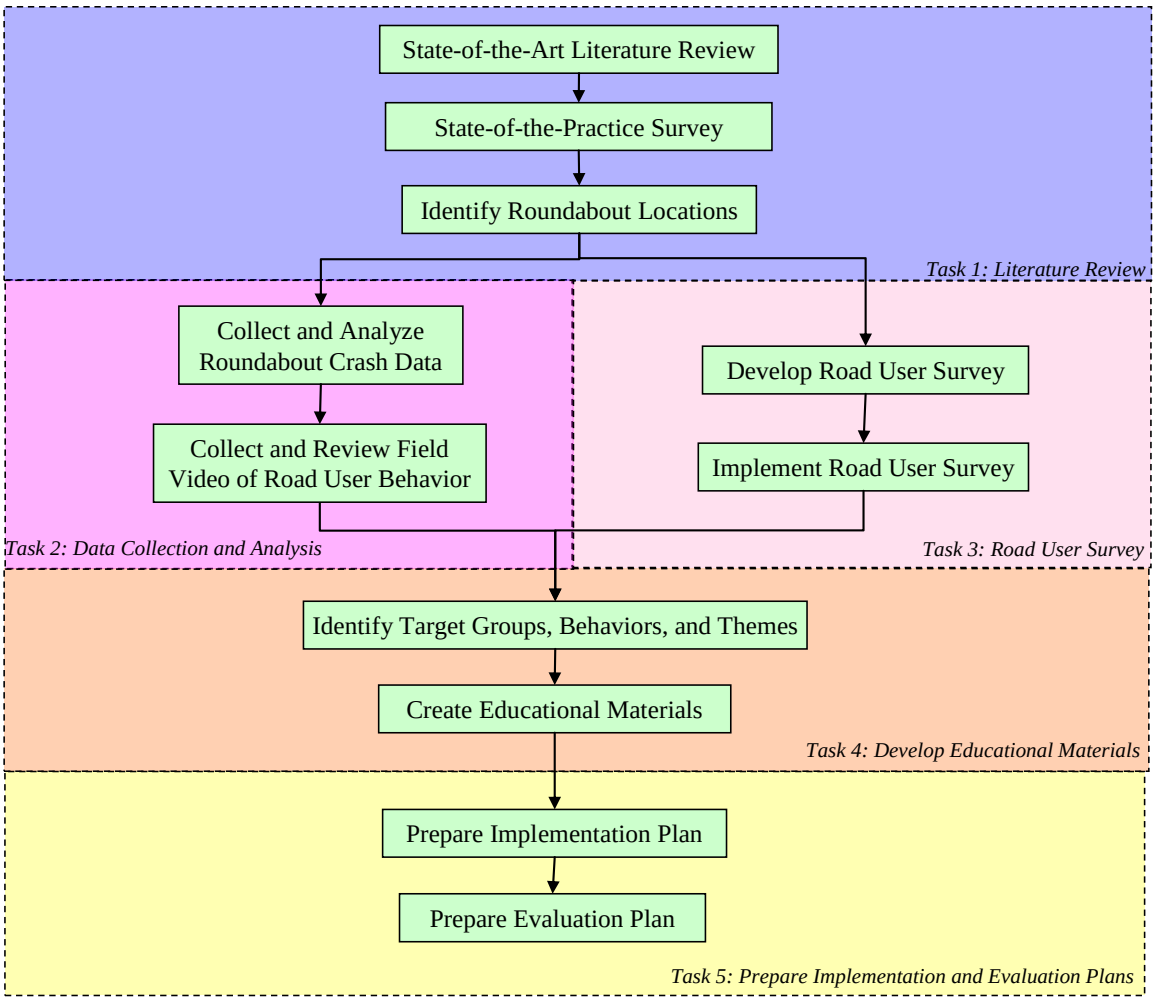


FIGURE 1: Methodology Flow Chart

The tasks conducted as a part of this study are summarized in this section of the report and a complete description of the work that was performed specific to each task is provided in the corresponding Chapters of this report.

- **Literature Review (Chapter 4)**. A comprehensive, state-of-the-art literature review was conducted of research related to public education and outreach programs aimed at raising public awareness regarding roundabouts. To supplement the results of this literature review, a questionnaire survey was developed and disseminated at both the national and state level. This survey sought detailed information on public information and education (PI&E) programs aimed at improving traffic safety, specifically those related to roundabouts. The survey was distributed to all 50 state departments of transportation, as well as those road agencies with jurisdiction over existing or proposed roundabouts in

Michigan using Zoomerang™ in order to facilitate timely feedback. A comprehensive list of all roundabouts that have been constructed or are scheduled for construction in the near future in the State of Michigan was identified in coordination with MDOT. In addition to identifying each roundabout location, further information was collected regarding the dates of construction and when each roundabout was opened to the public.

- **Data Collection and Analysis (Chapter 5)**. Crash data were collected for each of the roundabouts identified in the State of Michigan for the year 2009. These data were summarized and analyzed at a disaggregate level to determine general trends and patterns common to Michigan roundabouts. An in-depth analysis of the crash data was also conducted to identify common causal factors related to various types of roundabout crashes and at-risk groups of road users. This analysis included a critical review of the individual crash report forms (UD-10). To supplement the results of the crash data analysis, field studies were conducted at a sample of roundabout locations in order to gain further insight on difficulties experienced as drivers, pedestrians, and bicyclists attempt to negotiate roundabouts. To collect these field data, a data collection team recorded high-definition videos using a series of cameras located near each roundabout, which captured traffic entering and exiting the study locations.
- **Road User Survey (Chapter 6)**. In addition to these data-driven approaches to assessing roundabout operations, public acceptance of roundabouts is also an important concern of road agencies. Public concerns may potentially delay the introduction of roundabouts at locations where traffic operations and safety may be improved by such installations and such concerns may be due to unfamiliarity or misinformation, among other reasons. To assess issues of public concern, a road user survey was developed to obtain public feedback on roundabouts. This survey solicited feedback on numerous issues, including general perceptions of roundabout operations, positive and negative experiences associated with negotiating roundabouts, and points of confusion or difficulty from a user standpoint.
- **Develop Educational Materials (Chapter 7)**. In order for the driving public to realize the operational and safety benefits made possible by roundabouts, the drivers must be informed about the appropriate right-of-way laws and functional operations of roundabouts. These educational efforts, which can be conducted before and after

construction of the roundabout, aid in providing safe, efficient, and effective operations. The crash, behavioral, and survey data that were collected were used to identify behaviors and actions that most commonly contribute to roundabout crashes. These data provided a broad range of information that was utilized to develop educational materials targeted toward addressing correctable driver behavioral issues at roundabouts.

- **Conclusions, Implementation and Evaluation (Chapter 8)**. The products and materials developed included printed content, as well as videos and animations, each of which can be delivered through a variety of settings. To facilitate the successful and continued implementation of the products developed as a part of this study, recommendations for the implementation and evaluation of these materials were developed to assist MDOT and other transportation agencies in their effective use.

4.0 LITERATURE REVIEW

At the onset of this project, one of the first tasks involved preparing an inventory list of existing roundabouts throughout the State of Michigan. In coordination with MDOT, local agencies, and other resources, a total of 98 roundabouts were identified throughout the state that have been constructed or are scheduled for construction as of the winter of 2010. A list of these locations is shown in Table 1.

Aside from preparing the roundabout inventory, the primary purpose of the literature review was to conduct a systematic search to identify, critique, and summarize published studies and documented agency experiences with roundabouts, placing particular emphasis on road user perceptions of roundabouts and the utilization of public awareness programs by road agencies to familiarize users with their appropriate use.

TABLE 1a. List of Michigan Roundabouts

County	City	Intersection
Berrien	Benton Harbor	Main St./ I-94 Business Loop @ Riverview
Berrien	Benton Harbor	Main St./ I-94 Business Loop @ 5th St.
Calhoun	Homer	Hillsdale @ Main
Calhoun	Marshall	W. Michigan Ave. @ Kalamazoo
Calhoun	Homer	28 Mile Rd. @ M-60
Eaton	Delta Township	Willow Hwy @ Canal Rd.
Eaton	Dimondale	East Rd. @ Creyts Rd.
Grand Traverse	Traverse City	Birch Tree Ln @ Glen Dr.
Ingham	Lansing	Moores River @ Boston/Pattengill
Ingham	East Lansing	Bogue @ Shaw
Ingham	Meridian Township	Bennett Rd. @ Hulett Rd.
Ingham	Meridian Township	Hamilton @ Marsh
Ingham	Lansing Township	Lake Lansing @ Chamberlain
Ingham	Lansing Township	Wood St. @ Sams Way
Ingham	Lansing	Michigan @ Washington
Ingham	Lansing	Beal Ave. @ E. Barnes Ave.
Ingham	Lansing	Harding Ave. @ Pershing Dr.
Ingham	Holt	Holbrook @ Cedar
Iron	Alpha	Main/4th @ 8th/Center
Isabella	Mount Pleasan	Mosher @ Main
Isabella	Clare	US-127 Business Route @ Mission Road
Jackson	Jackson	West Ave. @ 4th Street
Kalamazoo	Kalamazoo	W. Michigan @ Rankin/ Knollwood
Kalamazoo	Vicksburg	Lotus Lily Ave. @ Trillium Blvd.
Kalamazoo	Kalamazoo	Emajean St. @ Arboretum Cir.
Kalamazoo	Kalamazoo	Howard @ S. Kendall Ave.
Kalamazoo	Kalamazoo	Howard @ Solon St.
Kent	Grand Rapids	Pfeiffer Woods West @ Pfeiffer Woods East
Kent	Grand Rapids	Cherry Street @ Jefferson Ave
Kent	Rockford	Sunset Ridge @ Saddle Ridge
Kent	Plainfield Township	Seven Mile @ Brewer
Kent	Grand Rapids	Jefferson @ Wealthy
Kent	Grand Rapids	Lafayette @ Wealthy
Livingston	Green Oak Township	Lee Road @ Whitmore Lake Road
Livingston	Green Oak Township	Lee Road @ US 23
Livingston	Green Oak Township	Lee Road @ Fieldcrest
Livingston	Brighton	Main St. @ 3rd Street
Livingston	Brighton Township	Kensington @ Jacoby
Livingston	Green Oak Township	Green Oak Ave. and Village Place Blvd.
Livingston	Green Oak Township	Green Oak Ave. and Village Place Blvd.
Livingston	Brighton	Winans Lake @ Hamburg
Livingston	Hartland	Hartland Road @ Hartland Square

TABLE 1b. List of Michigan Roundabouts (Continued)

Macomb	Sterling Heights	Utica @ Dodge Park
Macomb	Shelby Township	25 Mile @ Hayes
Macomb	Sterling Heights	M-53 (Van Dyke) @ 18 1/2 Mile Road
Macomb	Utica	Utica Park Dr. @ Utica Park Ave.
Macomb	Washington	Plantation @Charleston/Stratford
Macomb	New Baltimore	W. Vergote @ Waterside
Macomb	Shelby Township	SB M-53 @ 26 Mile
Macomb	Shelby Township	NB M-53 @ 26 Mile
Macomb	Clinton Township	Romeo Plank @ 19 Mile Road
Macomb	Clinton Township	Romeo Plank @ Cass Ave.
Macomb	Clinton Township	Romeo Plank @ Canal St.
Manistee	Manistee	Lakeshore @ Monroe/Cottage Ln.
Marquette	Marquette	US-41 and Front St
Montcalm	Greenville	Meijer Dr. @ Greenville West Dr.
Muskegon	Muskegon	W. Western Ave @ 3rd St.
Muskegon	Muskegon Township	Chesapeake @ Walker
Muskegon	Casnovia	M-46 @ M-37
Oakland	Rochester Hills	Tienken @ Sheldon
Oakland	Rochester Hills	Tienken @ Runyon/ Washington
Oakland	Orion Township	Baldwin @ Indianwood/Coats Road
Oakland	Commerce Township	Loop Rd. @ Commerce Crossing
Oakland	West Bloomfield Township	W. Maple Rd @ Drake Rd
Oakland	West Bloomfield Township	W. Maple Rd @ Farmington Rd.
Oakland	White Lake	Cooley Lake Road @ Oxbow Lake Road
Oakland	Commerce	Bogie Lake Rd. @ Cooley Lake Rd.
Oakland	Farmington Hills	14 Mile Rd @ Farmington Rd
Oakland	Northville	Morgan Blvd. @ Taft Rd.
Oakland	Wixom	Chambers @ Renton St.
Oakland	New Hudson	Grand River @ Lyon Center (West)
Oakland	Highland	White Lake @ Rose Center
Oakland	Highland	White Lake @ Duck Lake
Oakland	Walled Lake	Martin @ Oakley Park
Oakland	New Hudson	Grand River @ Lyon Center (East)
Oakland	Walled Lake	Oakley Park @ Martin Parkway/Martin Road
Oakland	Walled Lake	Martin Parkway @ PGA Dr.
Oakland	Walled Lake	Martin Parkway @ Library Dr.
Oakland	Rochester Hills	Hamlin Road @ Livernois Road
Oakland	New Hudson	Pontiac Trail @ Lyon Center Drive
Otsego	Livingston Twp	Old-27 @ Livingston Blvd
Ottawa	Coopersville	68th Ave @ Randall
Saginaw	Buena Vista Township	SB I-75 @ M-81
Saginaw	Buena Vista Township	NB I-75 @ M-81
Van Buren	South Haven	M-43 @ 12th St/72nd St

TABLE 1c. List of Michigan Roundabouts (Continued)

Washtenaw	Pittsfield Township	Campus Pkwy @ Suncrest
Washtenaw	Pittsfield Township	Campus Parkway @ Community Dr
Washtenaw	Ann Arbor	M-14 (east) @ Maple
Washtenaw	Ann Arbor	M-14 (west) @ Maple
Washtenaw	Ann Arbor	Maple Rd. @ Skyline H.S.
Washtenaw	Ann Arbor	Geddes Road @ Superior Road
Washtenaw	Ann Arbor	Geddes Road @ Earhart
Washtenaw	Ann Arbor	Huron @ Nixon
Washtenaw	Ann Arbor	Ann St. @ Observatory St.
Washtenaw	Ypsilanti Township	Whittaker Road @ Stoney Creek Road
Washtenaw	Ann Arbor	NB US-23 @ Geddes Road
Washtenaw	Ann Arbor	SB US-23 @ Geddes Road
Wayne	Taylor	Lakeview Dr. @ Island Lake Dr.

4.1 Synopsis of Public Perceptions of Roundabouts

Various studies have examined the public perspective on current, under-construction, or future roundabouts at specific locations throughout the USA. Some of the most current studies are described here.

Redington [*18*] conducted a survey of persons who lived and worked near a single-lane roundabout at Keck Circle in Montpelier, VT. A total of 111 respondents were interviewed through telephone, door-to-door, and workplace surveys. Among surveyed road users, "favorable" and "very favorable" responses outnumbered "unfavorable" and "very unfavorable" responses by a four-to-one margin. There was very little variation in perceptions among walkers, bicyclists, and drivers. Positive survey responses stressed the smooth flow of traffic, the increased ease of accessing businesses adjacent to the intersection, the attractiveness of the roundabout, and its safety. Negative survey responses centered on driver behavior - failure to yield, drivers not following the rules, and need for education of drivers.

Garder [*19*] analyzed the long-term effects of the reconstruction of a single-lane roundabout in Gorham, ME. Questionnaire surveys were used to gather opinions of motorists and residents in the vicinity of the roundabout on four different occasions: before reconstruction, just after reconstruction, as well as three years and five years later. The sample size of interviewed

motorists ranged from 65 to 110 on each occasion. Residents near the roundabout were more positive than those living further away. Over time, respondents tended to be more favorable regarding roundabouts and this change in attitude generally continued in the years following construction as drivers become more familiar with roundabouts.

Retting et al. investigated public opinion, as well as traffic flow before and after construction of several roundabouts at site-specific locations [*8, 9, 10*]. The methodology of these studies included representative random-digit-dial telephone surveys conducted approximately six weeks before and eight weeks after the roundabouts were constructed. These interviews were confined to respondents who said they drove through the study intersection frequently or occasionally and separate 300-person samples were collected during the periods both before and after implementation.

In 2002, Retting et al. [*8*] examined public perceptions regarding a single-lane roundabout in Harford County, MD that was part of a roadway realignment project. A substantial change in public opinion was indicated after construction when the proportion of drivers opposed to the roundabout declined from 38 percent to 22 percent and the proportion "strongly opposed" declined from 26 percent to 11 percent. The proportion of the drivers favoring the roundabout increased from 44 percent to 67 percent. In a similar study conducted for a roundabout at the intersection of Maryland State Routes 24 and 165, Retting et al. [*8*] found that the proportion of drivers opposing the roundabout declined from 65 percent to 32 percent, and the proportion "strongly opposed" declined from 51 percent to 18 percent. Likewise, in another study in Kansas, Retting et al. showed that the majority of drivers (60 percent) opposed the planned installation of a roundabout before construction, with 44 percent strongly opposed. After construction, there was a substantial change in public opinion. The proportion of drivers opposed to the roundabout declined from 60 percent to 30 percent, and the proportion strongly opposed declined from 44 percent to 15 percent. The large reduction in the proportion of drivers strongly opposed to the roundabout provides evidence that opinions of even those with strong negative perceptions initially tend to become more accepting of roundabouts over time.

In 2006, Retting et al. followed the same procedure to examine public opinion of a roundabout at the intersection of Route 29 and Route 40 in Greenwich, NY [*9*]. The analysis revealed that after construction, the proportion of drivers favoring the roundabout increased from 37 percent to 53 percent. Drivers opposed to construction of the roundabout provided multiple reasons, the most common being that the roundabout was confusing or unsafe. Similar results were obtained from analyses conducted in Nashua, NH and Bellingham, WA produced comparable trends as the proportion of drivers opposed to the roundabout declined from 53 percent to 38 percent. Although public opinion became more positive after construction, the change was modest at the site in Bellingham compared with other study sites. One reason could be that the prior form of traffic control was 4-way stop, which provides a high level of safety and simplicity for drivers.

Retting et al. [*10*] also conducted long-term follow-up surveys of public opinion and attitudes toward roundabouts in six communities one to five years after the roundabouts were constructed. For all six communities combined, the proportion of drivers in favor of the roundabouts increased from 34 percent before construction to 57 percent soon after roundabouts were built and to 69 percent after roundabouts were in place for 1 year or more. Opinion data were also analyzed by driver age and gender. Younger drivers (ages 18 to 34) generally expressed greater support, and older drivers (65 and older) generally were less in favor. Gender differences were small and not significant. Overall, about half of respondents thought roundabouts made intersections safer and reduced traffic congestion. Almost three times as many drivers said roundabouts made intersections safer than said roundabouts made intersections less safe and five times as many said roundabouts reduced traffic congestion as said roundabouts increased congestion. Drivers opposed to construction of the roundabouts were asked why they were opposed. Some respondents provided multiple reasons, the most common being that roundabouts were confusing or unsafe. This series of surveys indicates that many drivers are skeptical or opposed to roundabouts when they are proposed. However, drivers generally become more supportive of roundabouts after they are built, and this change in attitude generally continues in the years following construction as drivers become more familiar with roundabouts.

In a study conducted by the City of Olathe [*20*], residents were interviewed by telephone to obtain their opinions about specific roundabouts located in the city. A sample was used that

consisted of two sub-groups: a) an area sample consisted of people who lived in close proximity to the roundabouts, and; b) a city sample including persons who lived throughout the city. Persons in the first group were more likely to feel their travel time along the route had decreased and were also more supportive of roundabouts in other areas of the city. This survey provides further evidence that exposure increases driver familiarity, comfort, and perceived safety of roundabouts.

4.2 Concerns Related to Specific Groups of Road Users

Other research has shown that specific groups of road users, such as older drivers and non-motorized transportation users, may be particularly vulnerable at intersections. In one of these studies, Lord et al. [*16*] identified elements of roundabout design and operations that were problematic for older drivers and developed recommendations for countermeasures with the potential to improve comfort, confidence, and safety for seniors using roundabouts. Four focus groups were held, including 41 subjects above age 65. A moderator explained characteristics of roundabouts using drawings and video. A qualitative assessment of data was also conducted to identify design elements of roundabouts that may be problematic to older drivers. Some of the older drivers commented that single lane roundabouts did not provide room to maneuver in the event of driver error. These drivers also commented that it was difficult to understand the rules governing yield signs at single lane roundabouts and they were confused about whether drivers must stop when entering roundabouts when no vehicle is present. The participants were in unison about being properly warned of upcoming roundabouts by signing, preferring advance warning signs to show the number of lanes within the roundabout and the speed limit for vehicles approaching the roundabout. Most of the drivers preferred pictogram signs rather than the words "roundabout ahead." At the entrance of the roundabout the older drivers commented that they were confused by yield signs and had difficulty understanding the rules governing the yield signs, as well as the yield sign symbols on the pavement. The participants expressed they would prefer street names signs with arrow pointing toward the exit located on the splitter island rather than the traveled way prior to reaching the exit.

In 2009, Dissanayake and Perera conducted a study with the intent to identify characteristics of older drivers involved in crashes at various types of roundabouts in Kansas [*21*]. In addition, a

survey was conducted focusing on identifying older-driver behaviors, potential problems, and level of exposure to various traffic conditions. Older driver surveys were conducted at senior centers and churches in eight Kansas cities. The survey sample included older drivers that actively and routinely drive and these drivers generally considered roundabouts more difficult to deal with than the other types of intersections.

Hydén and Várhelyi [*22*] conducted an experiment with small roundabouts as speed reducing measures. The purpose of the study was to test the large scale and long-term effects of single-lane roundabouts. Interviews were conducted 4 months after roundabout implementation with drivers and bicyclists who were stopped at the side of the road. Follow-up interviews were conducted 4 years later with 125 road users: 25 drivers of private cars, 26 bicyclists, 26 pedestrians, and 48 professional drivers (emergency, taxi, truck, and bus). Interviews conducted 4 months after implementation revealed mixed opinions. Some intersections were considered less safe as a result of the roundabout construction, and others were considered safer. Car drivers were less positive than bicyclists. Both drivers and bicyclists referred to lower vehicle speeds as the cause for safety improvement. The authors indicated that 70 percent of road users claimed that safety improved and traffic became smoother with the help of roundabouts. Results from pedestrian surveys showed mixed feelings for the roundabouts. About 40 percent of interviewed pedestrians said roundabouts made it easier to cross while 20 percent said it became more difficult.

Previous research has indicated that conversions of intersections to roundabouts appear to increase the number of injury crashes with bicyclists. Daniels et al. [*23*] conducted regression analyses on effectiveness-indices resulting from a before-and-after study of injury crashes with bicyclists at 90 roundabouts in Flanders, Belgium. Regarding all injury crashes with bicyclists, roundabouts with cycle lanes appear to perform significantly worse compared to three other design types (mixed traffic, separate cycle paths, and grade-separated cycle paths).

A study was carried out by Jørgensen and Jørgensen [*24*] with the aim of finding out how roundabouts ought to be designed in order to provide cyclists with the highest level of safety possible. Seven urban roundabouts of different designs were analyzed through video recordings.

Entry and exit flows, errors in the use of the roundabouts by cyclists, and interaction with other road users were recorded. At all roundabouts, the cyclists were in some way separated from motorized traffic, either by a solid white line forming an outer circle, or by small islands. The conclusion was that cyclists do not obtain the same safety effect as motorists at roundabouts. Information available on the design of the evaluated roundabouts was rather poor, but all seven of them seemed to be rather large. The authors suggest that traffic safety could be improved for cyclists if the inscribed diameter of the roundabout was smaller. At mini-roundabouts, all road users have to share the circling area, which promotes interaction and safety.

Pedestrian and cyclists involved in crashes were surveyed by Turner et al. [*25*] in order to obtain data on the number of such crashes that involved a motor vehicle, and to obtain details of the crashes not readily available from police reports. Of all reported pedestrian crashes at roundabouts, 70 percent involved a vehicle approaching from either the left or right side of the pedestrian. Of all reported urban cycle accidents, nine percent occurred at roundabouts. Right angle collisions were the predominant crash type, accounting for 57 percent. The other most common type of cyclist crash involved collisions between entering motor vehicles and circulating bicyclists.

Geruschat and Hassan [*26*] evaluated driver behavior in yielding the right-of-way to sighted and blind pedestrians who stood at different stopping distances from the crosswalk lines at entry and exit lanes at two different roundabouts. Study sites were double-lane roundabouts in Annapolis, MD. The authors reported a significant relationship between the speed of vehicles and drivers' yielding behavior. As vehicular speed decreased, yielding behavior increased and vice versa. Specifically, at low speeds (less than 15 mph), drivers yielded approximately 75 percent of the time, whereas at higher speeds (greater than 20 miles per hour), they typically yielded less than 50 percent of the time. The study found a significantly higher percentage of drivers yielded to pedestrians when entering the roundabout than when exiting. At speeds of 10-11 mph, 99 percent of drivers yielded when entering the roundabout, but only 60 percent yielded when exiting the roundabout. At speeds of more than 20 mph, approximately 65 percent of drivers yielded on entering the roundabout, but only 10 – 15 percent did so when exiting. A second analysis evaluated the presence or absence of a long cane on drivers' yielding behavior with respect to

visually impaired pedestrians. When a long cane was present, drivers yielded 63 percent of the time, whereas when the long cane was not present, they yielded 52 percent of the time.

4.3 State-of-the-Practice Survey

To supplement the results of the literature review, a state-of-the-practice survey was also implemented in order to gain insight as to the current practices of state and local agencies regarding public education programs, specifically with respect to roundabouts. This survey built upon the results of a previous survey conducted as a part of NCHRP Synthesis 264 [*2*], which involved mail surveys of each State DOT in the US, to each province in Canada, and to 26 U.S. municipalities and counties known to have roundabouts. A total of 44 State DOTs responded to the NCHRP survey, of which nine reported to have roundabouts in operation, under construction, or in design. Each respondent was asked about existing public awareness programs related to roundabouts at their agency. Of all survey respondents, 30 percent indicated that they held special public meetings, 30 percent published informational brochures, 9 percent announced the change on local TV or produced a video, and 30 percent of agencies did not do anything specifically related to roundabouts on a regular or project-specific basis [*2*].

A subsequent review of four state roundabout development programs was conducted by Pochowski and Myers [*27*]. The study reviewed a number of issues related to roundabout deployment, including driver education, public acceptance, and education. The four states reviewed were Kansas, Maryland, New York, and Wisconsin. The authors report that each state has addressed the issue of public acceptance through the publication and distribution of brochures or handouts made available at public meetings. The authors report that Maryland has had more success in overcoming public reluctance towards roundabouts than Kansas. Much of the lack of acceptance in Kansas was attributed to road user exposure as Kansas at the time of the study had only deployed nine roundabouts, whereas Maryland had deployed 65. The authors note that education had expanded to include not only the operation of roundabouts, but also the difference between traffic circles and roundabouts. In areas where many traffic circles exist or have failed, the authors stress the importance of educating the public on the difference between roundabouts and traffic circles. The authors also acknowledge the need to educate agency staff to ensure their understanding of the difference between roundabouts and circles and to also

provide them the training necessary to analyze the operational performance of roundabouts and the latest geometric design standards [*27*].

The state-of-the-practice survey, developed in consultation with MDOT, is shown in Figure 2. This survey was hosted online using Zoomerang^{TM} [*28*] in order to facilitate timely feedback from participating agencies. Invitation e-mails were sent to representatives from all 50 state departments of transportation (DOTs), as well as to representatives from local road agencies and county road commissions in the State of Michigan. In addition, information regarding the survey was also disseminated through both the Transportation Research Board (TRB) Task Force on Roundabouts and the Institute of Transportation Engineers (ITE) Roundabout Task Force. A total of 73 survey responses were obtained, including 22 from DOTs and 51 from local road agencies. Survey results are presented in Table 2 and a brief synopsis follows.

Wayne State University Transportation Research Group
State-of-the-Practice Survey
Roundabout Public Information and Education Programs

The purpose of this survey is to collect information regarding the use of public information and education (PI&E) programs to improve road user knowledge of roundabouts by state, county and local road agencies. These data will be used in the design and development of subsequent PI&E programs in the State of Michigan. As a part of this research effort, the Wayne State University Transportation Research Group is compiling materials that have been developed as a part of other PI&E programs. If your agency has any such materials available, we would appreciate it if you could forward them to our care. Completed surveys can also be mailed, faxed, or e-mailed to us. Your participation in this effort and your responses to these survey questions would be greatly appreciated. If you have questions about this initiative, please feel free to contact me directly. Thank you in advance for your assistance.

Sincerely,

Peter T. Savolainen, Ph.D., P.E.
Assistant Professor of Civil Engineering
Wayne State University
5050 Anthony Wayne Drive
Detroit, MI 48202
Phone: (313) 577-9950
Fax: (313) 577-8126
E-mail: savolainen@wayne.edu

1. Your Name and Title: _____

   Agency Name: _____

   Address: _____

   Telephone No.: _____ E-Mail:_____

2. Is your agency currently constructing, or has it recently constructed any roundabouts?
   □Yes □No

3. Does your agency solicit public feedback prior to roundabout construction?
   □Yes □No
   If Yes, please describe how this feedback is obtained: _____

4. Has your agency conducted any public information and education (PI&E) programs related to roundabouts?
   □Yes □No

5. If your agency has conducted any roundabout public information and education (PI&E) programs, when have they been conducted? (Check all that apply)
   □Before construction of a specific roundabout □During construction of a specific roundabout
   □After construction of a specific roundabout □Periodically as part of a regional/statewide initiative
   □Other, please specify: _____

6. Has your agency conducted any public information and education (PI&E) programs related to other transportation issues?
   □Yes □No
   □If Yes, please list what issues such programs have focused on: _____

7. If your agency has conducted any PI&E programs, what type(s) of media/outreach were used? (Check all that apply)
   □ Public Hearings □ Internet Advertisements/E-mail
   □ Information Meetings/Q&A Sessions □ Radio Advertisements
   □ Newspaper Advertisements □ Letters/Mailings
   □ Television or Video Advertisements □ Other: _____

8. When PI&E programs are conducted by your agency, is program effectiveness measured in any way?
   □Yes □No

   If Yes, please describe: _____

FIGURE 2: State-of-the-Practice Survey Form

TABLE 2. State-of-the-Practice Survey Results

Question: Is your agency currently constructing, or has it recently constructed any roundabouts?						
Response	**State DOT**		**Local Agencies**		**All Agencies**	
Yes	19	86%	28	55%	47	64%
No	3	14%	22	43%	25	34%
Question: Does your agency solicit public feedback prior to roundabout construction?						
Response	**State DOT**		**Local Agencies**		**All Agencies**	
Yes	19	86%	31	61%	50	68%
No	2	9%	20	39%	22	30%
Question: Has your agency conducted any public information and education (PI&E) programs related to roundabouts?						
Response	**State DOT**		**Local Agencies**		**All Agencies**	
Yes	15	68%	21	41%	36	49%
No	7	32%	30	59%	37	51%
Question: If your agency has conducted any roundabout public information and education (PI&E) programs, when have they been conducted?						
Response	**State DOT**		**Local Agencies**		**All Agencies**	
Before Construction of a Specific Roundabout	13	59%	18	35%	31	42%
During Construction of a Specific Roundabout	6	27%	9	18%	15	21%
After Construction of a Specific Roundabout	7	32%	10	20%	17	23%
Periodically as part of a regional or statewide initiative	3	14%	9	18%	12	16%
None of these/Not applicable	5	23%	22	43%	27	37%
Question: Has your agency conducted any public information and education (PI&E) programs related to other transportation issues?						
Response	**State DOT**		**Local Agencies**		**All Agencies**	
Yes	19	86%	40	78%	59	81%
No	2	9%	11	22%	13	18%
Question: If your agency has conducted any PI&E programs, what type(s) of media/outreach were used?						
Response	**State DOT**		**Local Agencies**		**All Agencies**	
Public Hearings	15	68%	37	73%	52	71%
Informational Question and Answer (Q&A) Sessions	17	77%	28	55%	45	62%
Newspaper Advertisements	14	64%	26	51%	40	55%
Television or Video Advertisements	8	36%	11	22%	19	26%
Internet	14	64%	28	55%	42	58%
Advertisements/E-mail	7	32%	14	27%	21	29%
Radio	12	55%	15	29%	27	37%
Advertisements	6	27%	9	18%	15	21%
Letters/Mailings	11	50%	23	45%	34	47%
None of these/Not applicable	1	5%	8	16%	9	12%
Other	5	23%	10	20%	15	21%
Question: When public information and education (PI&E) programs are conducted by your agency, is the effectiveness of these programs measured in any way?						
Response	**State DOT**		**Local Agencies**		**All Agencies**	
Yes	9	41%	9	18%	18	25%
No	13	59%	42	82%	55	75%
NOTE: Percentages may not add up to 100% due to non-responses.						

Of the responding agencies, 86 percent of DOTs and 55 percent of local agencies indicated that their agency was currently constructing or had recently constructed a roundabout. This was a significant increase from the results of the 2003 survey, which indicated that only 20.5 percent of DOTs had roundabouts either in operation or in the planning or construction phase. Similar percentages of agencies also indicated that they solicited public feedback prior to roundabout construction, with this practice being more common among DOTs (86 percent) than local agencies (61 percent).

Among DOTs, 68 percent indicated that they had conducted a public information and education program related to roundabouts, compared to 41 percent of local agencies. These programs were predominantly conducted prior to the construction of a specific roundabout (42 percent overall) compared to the phases during (21 percent) and after (23 percent) construction. Periodic regional or statewide campaigns were conducted by 14 percent of DOTs and 18 percent of local agencies. The higher proportion of such campaigns among local agencies is likely due in part to the fact that roundabouts have recently been constructed in much greater numbers throughout Michigan whereas some states have installed roundabouts on a regular basis for nearly 20 years.

Public information campaigns related to any aspects of transportation were conducted with greater frequency as 86 percent of DOTs and 78 percent of local agencies indicated that they had participated in such programs. The most common type of educational programs conducted by state DOTs were information question-and-answer (Q&A) sessions (77 percent), followed by public hearings (68 percent), newspaper advertisements (64 percent), and internet-based communication (64 percent). These same delivery media were predominantly used by local agencies, as well.

Lastly, less than half of responding DOTs indicated that they conducted a formal assessment of their public information and education campaigns and fewer than 20 percent of local agencies evaluated campaign effectiveness. Among those agencies that did conduct evaluations, these assessments were generally simple and process-based (e.g., tracking the number of meeting attendees, number of advertisements run, etc.).

Details of State DOT Websites

As a part of the state-of-the-practice survey, each state department of transportation (DOT) website was also reviewed for content related to roundabouts between January and March of 2010. Some form of roundabout information was included on the websites for 29 of the 50 states, as well as on the FHWA website. This content varied substantially between agencies, ranging from project-specific roundabout informational flyers to more comprehensive information regarding various aspects of roundabout. The 19 states listed in Table 3 have websites specifically dedicated to roundabouts, as does the FHWA. Specific details of the type of content included on each website are provided in Table 4. Many of the websites reviewed included educational videos related to roundabouts. A list of 29 such videos is included in Table 5, several of which have been shared for use by various agencies.

TABLE 3 State DOT Roundabout Websites

State	Web Address
AK	http://www.dot.state.ak.us/stwdplng/projectinfo/ser/Sitka_Round/index.shtml
AZ	http://www.azdot.gov/CCPartnerships/Roundabouts/index.asp
CA	http://www.dot.ca.gov/hq/oppd/roundabt/
GA	http://www.dot.state.ga.us/travelingingeorgia/roundabouts/Pages/default.aspx
IA	http://www.iowadot.gov/roundabouts/roundabouts.htm
ME	http://www.maine.gov/mdot/roundabouts/
MD	http://www.sha.maryland.gov/Index.aspx?PageId=287
MI	http://www.michigan.gov/mdot/roundabout
MN	http://www.dot.state.mn.us/roundabouts/
MZ	http://www.modot.mo.gov/central/major_projects/roundabout.htm
MT	http://www.mdt.mt.gov/travinfo/roundabouts/
NV	http://www.nevadadot.com/roundabout/
NH	http://www.nh.gov/dot/org/projectdevelopment/highwaydesign/roundabouts/index.htm
NY	https://www.nysdot.gov/main/roundabouts
OR	http://www.oregon.gov/ODOT/HWY/ENGSERVICES/roundabout_home.shtml
PA	http://www.dot.state.pa.us/Internet/web.nsf/RoundaboutContactInfo?ReadForm&Click=
VA	http://www.virginiadot.org/info/faq-roundabouts.asp
WA	http://www.wsdot.wa.gov/safety/roundabouts/
WI	http://www.dot.state.wi.us/safety/motorist/roaddesign/roundabout.htm
FHWA	http://safety.fhwa.dot.gov/intersection/roundabouts/

TABLE 4 Summary of State DOT Website Information

State	Informational Brochure	Roundabout Information on Website Includes:							
		Safety/Operational Benefits	Details on Specific Locations	Single-lane vs. Multi-lane	Do Not Stop Within	Yield at Entry	Pedestrians /Bicyclists	Trucks	Lane Selection
AK	No	Yes	Yes	Single Lane	Yes	Yes	No	No	No
AZ	No	Yes	Yes	Both	Yes	Yes	Yes	Yes	Yes
CA	Yes	Yes	No	Non-specific	Yes	Yes	Yes	Yes	Yes
CO	No	Yes	Yes	Non-specific	Yes	Yes	Yes	No	No
CT	No	No	Yes	Non-specific	No	No	No	No	No
DE	Yes	Yes	Yes	Single	No	Yes	Yes	No	No
FL	Yes	No	No	Both	Yes	Yes	Yes	No	Yes
GA	Yes	Yes	Yes	Non-specific	No	Yes	Yes	Yes	No
IA	No	Yes	Yes	Non-specific	Yes	Yes	Yes	Yes	No
KS	No	Yes	No	Both	Yes	Yes	Yes	Yes	Yes
KY	No	No	Yes	Non-specific	No	No	No	No	No
ME	Yes	No	Yes	Non-specific	No	Yes	No	Yes	No
MD	No	Yes	Yes	Both	Yes	Yes	Yes	Yes	Yes
MI	Yes	Yes	Yes	Non-specific	Yes	Yes	Yes	Yes	Yes
MN	Yes	Yes	Yes	Non-specific	Yes	Yes	Yes	Yes	Yes
MO	Yes	Yes	Yes	Non-specific	Yes	Yes	No	No	No
MT	No	Yes	Yes	Non-specific	Yes	Yes	Yes	Yes	Yes
NE	Yes	Yes	Yes	Non-specific	No	Yes	No	No	No
NV	Yes	Yes	No	Both	Yes	Yes	Yes	Yes	Yes
NH	Yes	Yes	Yes	Both	Yes	Yes	Yes	Yes	Yes
NM	Yes	Yes	No	Non-specific	Yes	Yes	Yes	Yes	Yes
NY	Yes	Yes	Yes	Non-specific	No	Yes	Yes	Yes	Yes
OR	Yes	Yes	No	Non-specific	Yes	Yes	Yes	No	No
PA	Yes	Yes	No	Both	No	Yes	Yes	Yes	Yes
RI	Yes	Yes	No	Non-specific	No	Yes	No	No	No
VA	Yes	Yes	Yes	Both	Yes	Yes	Yes	Yes	Yes
WA	No	Yes	Yes	Both	Yes	Yes	Yes	Yes	Yes
WI	Yes	Yes	Yes	Both	Yes	Yes	Yes	Yes	Yes
WY	Yes	Yes	Yes	Single lane	No	No	No	No	No
FHWA	Yes	Yes	Yes	Both	Yes	Yes	Yes	Yes	Yes

TABLE 5 Roundabout Educational Videos

Video Developer	Video Web Location
Alaska DOT	http://www.dot.state.ak.us/stwdplng/projectinfo/ser/Sitka_Round/assetts/how_to_use_5_WMV_V9.wmv
Arizona DOT	http://www.azdot.gov/CCP/ModernRoundabouts/Details.wmv
Arizona DOT	http://www.azdot.gov/CCP/ModernRoundabouts/Introduction.wmv
Avon, Colorado	http://www.oregon.gov/ODOT/HWY/ENGSERVICES/images/avonrndabt.rm
Avon, Colorado	http://www.oregon.gov/ODOT/HWY/ENGSERVICES/images/roundabout.rm
Delaware DOT	http://deldot.gov/information/community_programs_and_services/roundabouts/index.shtml
IIHS	http://www.iihs.org/video.aspx/info/roundabout
Kansas DOT	http://www.ksdot.org:9080/burTrafficEng/Roundabouts/Roundabout_Guide/roundabout.wmv
Kansas State University	http://www.k-state.edu/roundabouts/videos/afterlisbon2.mpg
Kansas State University	http://www.k-state.edu/roundabouts/videos/beforelisbon.mpg
Kansas State University	http://www.k-state.edu/roundabouts/videos/brunswick.mpg
Kansas State University	http://www.k-state.edu/roundabouts/videos/firetruck.mpg
Kansas State University	http://www.k-state.edu/roundabouts/videos/upstruck.mpg
Kansas State University	http://www.k-state.edu/roundabouts/videos/Video1.avi
Kentucky DOT	http://transportation.ky.gov/D4/Roundabout.html
Michigan DOT	http://www.youtube.com/watch?v=JqaFq4ZFNpo
Michigan DOT	http://www.youtube.com/watch?v=sgzgBqX8jAM
Minnesota DOT	http://www.dot.state.mn.us/roundabouts/videos/how-about.wmv
Missouri DOT	http://media.deldot.gov/media/video/public_relations/roundabouts/missouriDOT.wmv
MORPC - Ohio	http://www.morpc.org/transportation/Rules_Of_The_Road/RoundaboutLongStream.wmv
MORPC - Ohio	http://www.morpc.org/transportation/Rules_Of_The_Road/RoundaboutShortStream.wmv
Nebraska Department of Roads	http://www.vimeo.com/9576402
Nevada DOT	http://www.nevadadot.com/safety/roundabout/videos.asp
New York State DOT	mms://mds.nysdot.gov/dotmedia/mexis/design/green_win2005.wmv
New York State DOT	mms://mds.nysdot.gov/dotmedia/mexis/design/oversize.wmv
Pennsylvania DOT	ftp://ftp.dot.state.pa.us/public/Bureaus/design/Roundabouts/Shockwave%20Files/4501m001_july12th2004.swf
RTC Washoe County, NV	http://66.209.78.73/videos/misc/roundabouts/roundabouts.html
Washington DOT	http://media.deldot.gov/media/video/public_relations/roundabouts/WSDOT.wmv
Wisconsin DOT	http://media.deldot.gov/media/video/public_relations/roundabouts/WIS_Dot.wmv

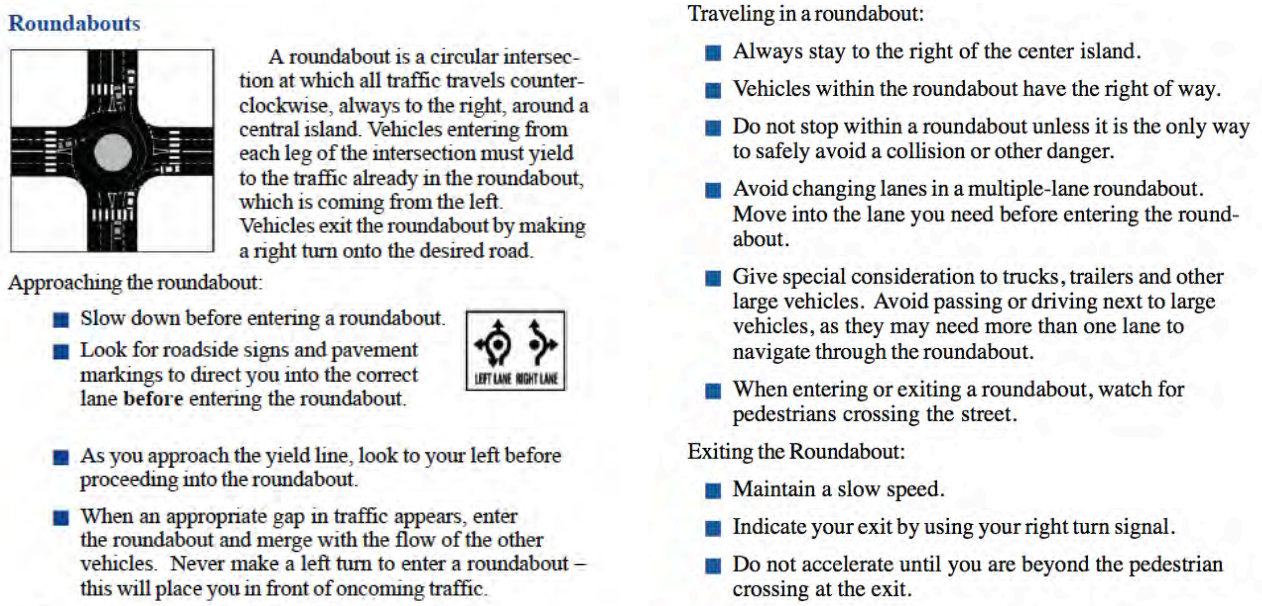
Summary of State Driver Education Materials Related to Roundabouts

One means of addressing confusion regarding the rules of the road associated with roundabouts is through driver education and training, which introduces drivers to right-of-way rules and other relevant traffic laws. However, a 2003 review of the driver education manuals of all fifty states indicated that very little information is provided regarding roundabouts in most states [*29*]. In fact, it was found that the roundabout information in most manuals was provided in one sentence. Some states still referred to roundabouts as traffic circles, a label which more accurately refers to the less safe and less efficient predecessor to today's modern roundabout. In fact, past research shows that public buy-in to roundabouts is often clouded by confusion of motorists who have previously had bad experiences in the modern roundabout's predecessor, the traffic circle [*30*]. Since this most recent evaluation, there has been substantial progress nationwide in terms of roundabout coverage in training manuals.

Each state has a unique driver's manual or handbook aimed at providing information about traffic laws, rules of the road, and traffic safety, such as the Michigan Secretary of State's *What Every Driver Must Know*. The driver's manuals/handbooks for all 50 states were reviewed for information specific to roundabouts and this review found 35 States, listed in Table 6, that currently include information on roundabouts in their driver education literature. An excerpt of the material from the Michigan Secretary of State's *What Every Driver Must Know* is shown in Figure 3.

TABLE 6. States Including Roundabout Information in Driver's Manual

• Alaska	• Hawaii	• Maryland	• Nevada	• South Carolina
• Arizona	• Idaho	• Massachusetts	• New Jersey	• Tennessee
• California	• Indiana	• Michigan	• New York	• Utah
• Colorado	• Iowa	• Minnesota	• North Dakota	• Vermont
• Connecticut	• Kansas	• Missouri	• Oregon	• Virginia
• Florida	• Kentucky	• Montana	• Pennsylvania	• Washington
• Georgia	• Maine	• Nebraska	• Rhode Island	• Wisconsin



Roundabouts

A roundabout is a circular intersection at which all traffic travels counterclockwise, always to the right, around a central island. Vehicles entering from each leg of the intersection must yield to the traffic already in the roundabout, which is coming from the left. Vehicles exit the roundabout by making a right turn onto the desired road.

Approaching the roundabout:

- Slow down before entering a roundabout.
- Look for roadside signs and pavement markings to direct you into the correct lane **before** entering the roundabout.

- As you approach the yield line, look to your left before proceeding into the roundabout.
- When an appropriate gap in traffic appears, enter the roundabout and merge with the flow of the other vehicles. Never make a left turn to enter a roundabout – this will place you in front of oncoming traffic.

Traveling in a roundabout:

- Always stay to the right of the center island.
- Vehicles within the roundabout have the right of way.
- Do not stop within a roundabout unless it is the only way to safely avoid a collision or other danger.
- Avoid changing lanes in a multiple-lane roundabout. Move into the lane you need before entering the roundabout.
- Give special consideration to trucks, trailers and other large vehicles. Avoid passing or driving next to large vehicles, as they may need more than one lane to navigate through the roundabout.
- When entering or exiting a roundabout, watch for pedestrians crossing the street.

Exiting the Roundabout:

- Maintain a slow speed.
- Indicate your exit by using your right turn signal.
- Do not accelerate until you are beyond the pedestrian crossing at the exit.

FIGURE 3. Excerpt from *What Every Driver Must Know* (Michigan)

There was substantial variability in the depth and breadth of coverage among the states that included roundabout information in their driver's manuals/handbooks. Some states simply provide a brief definition of roundabouts while other states include more in-depth information about specific groups of road users, the proper way to navigate a roundabout, safety and operational benefits, and other items.

A total of 30 state manuals/handbooks included a section that provided a general description of how to properly navigate a roundabout. These sections were short and simple in some states and more thorough in others. An example of a short, simple description of how to use a roundabout is shown from the State of Missouri:

> *"At a roundabout, drivers who approach the intersection make a slight right turn to go counterclockwise around a circular center island. The driver may then either exit the roundabout onto a different roadway, or continue on the same roadway. When approaching a roundabout, always yield to traffic in the circle and pedestrians in the crosswalks."*

Other States include a step-by-step procedure on the correct way to drive a roundabout. The State of Nevada provides such an example:

1. *As you approach, choose which lane to use as you would for any other intersection. Use the left lane to turn left, complete a U-turn or go straight. Use the right lane to turn right or go straight.*
2. *Yield. Those in the roundabout have the right-of-way. Wait for a gap in traffic.*
3. *All vehicles in the roundabout travel in ONE DIRECTION-counterclockwise.*
4. *Never change lanes. If you are in the inside lane and miss your exit, you must continue around until you reach the exit again.*
5. *Use your right turn signal when exiting.*

Information regarding specific groups of road users, such as non-motorized users or commercial vehicle drivers, is covered to varying degrees by particular states. The manuals/handbooks for 13 states provide content specific to pedestrian activity at roundabouts. This information generally instructs drivers to expect pedestrian activity when entering or exiting roundabouts and to yield accordingly. Instructions aimed at pedestrians on how to safely cross roundabout legs were also included in 7 manuals/handbooks, such as this example from Rhode Island:

a. *APPROACH: Pedestrians should look left upon arriving at a crosswalk in search of oncoming vehicles and bicycles.*
b. *CROSS: Pedestrians should cross to the raised or painted splitter or refuge. Then, look right and finish crossing to the opposite sidewalk.*
c. *Pedestrians should never walk through a roundabout or cross the center island.*

The same 13 states with pedestrian information also included content regarding bicyclists at roundabouts and 8 of these states included a specific section to inform the bicyclists of how to use the roundabout. It is generally noted by these states that a bicyclists should dismount their bicycle and use the crosswalk in the same manner as a pedestrian, though some indicate that cyclists can also use the roundabout in the same manner as a motor vehicle. In such cases, bicyclists are instructed to ride in the middle of the lane so that vehicles can clearly see them and will not pass them and to indicate when turning or continuing through the roundabout. The Iowa manual/handbook states:

> *"Generally, cyclists should walk their bicycles across the pedestrian crosswalk using the same rules as pedestrians. Experienced cyclists may navigate roundabouts like motorists.*

Do not hug the curb. Bicyclists using the roundabout should follow the same rules as motorists. Ride in the middle of the lane to prevent vehicles from passing. Yield to pedestrians in crosswalks."

Trucks and other large vehicles are frequently cited as a group that is prone to difficulty in negotiating roundabouts. Of the content reviewed, 9 states had information related to trucks and other large vehicles. This content generally addressed the issue that trucks require more space within the roundabout and that it is important for vehicles to not travel next to or try to pass trucks or busses within a roundabout. The state manuals/handbooks also note that roundabouts accommodate the wide turning radii of the vehicles by providing a mountable truck apron around the central island. The State of Maryland provides the following paragraph in the Driver's Handbook on Large Vehicles:

Do not overtake large vehicles. Large vehicles (for example, trucks and buses) may have to swing wide on the approach to or within the roundabout. Watch for their turn signals and give them plenty of room, especially since they may obscure other vehicles. Large vehicles may need to use the full width of the roadway, including mountable aprons provided to negotiate a roundabout. Their drivers should be careful of all other users of the roundabouts and, prior to entering the roundabout, satisfy themselves that other users are aware of them and will yield to them."

Emergency Vehicle Policies

Driver behavior during emergency vehicles runs is also addressed by 8 of the state driver's manuals/handbooks, though there was some variability in the rules from state to state. As such, the search of each state's driver manual/handbook was supplemented by examining other sources, including other state and local agency websites. The results showed that at least 20 states have policies for driver actions when encountering an emergency vehicle approaches a roundabout as shown in Table 7.

Of these, 17 states instruct drivers who have not yet entered the roundabout to pull over and wait for the emergency vehicle to pass through the roundabout before entering. Once a driver has entered the roundabout, they are either instructed to proceed through to their exit (16 states),

proceed to the next immediate exit (3 states), or to pull over within the roundabout if space is available (6 states).

TABLE 7. State Roundabout Policies During Emergency Vehicle Runs

States instructing approaching drivers to pull over for emergency vehicles prior to entry					
California	Kentucky	Montana	New Mexico	Oregon	Washington
Indiana	Maryland	Nevada	New York	Pennsylvania	Wisconsin
Kansas	Michigan	New Hampshire	North Dakota	Virginia	
States instructing drivers to continue to their exit and then pull over for emergency vehicles					
Alaska	Kansas*	Montana	New Mexico	Oregon	Washington
California	Kentucky	Nebraska	New York	Virginia	Wisconsin
Illinois	Maryland*	New Hampshire	North Dakota		
States instructing drivers to exit immediately and then pull over for emergency vehicles					
Michigan	Minnesota	Pennsylvania			
States instructing drivers within the roundabout to pull over if roundabout is wide enough but prefer drivers to exit roundabout before pulling over for emergency vehicles					
Arizona	Georgia	Indiana	Iowa	Kansas*	Maryland*
*Indicates states with policies which provide alternatives for drivers					

5.0 CRASH ANALYSIS

In addition to the information obtained from the literature review, data related to the operational and safety performance of Michigan roundabouts were collected to assist in identifying themes for the subsequent educational materials. In particular, a crash data analysis was conducted, the results of which were supplemented by a series of field behavioral studies conducted at a sample of roundabout locations.

Crash data from the year 2009 were collected for each of the 39 roundabouts in the State of Michigan that experienced a traffic crash based upon a query of the MDOT Traffic Crash Reporting System (TCRS). Each form was carefully reviewed to understand where the crash occurred, when it occurred, how it occurred and why it occurred. By knowing this information, the subsequent educational materials were designed to focus on the issues identified through the analysis of the crash report (UD-10) forms. This manual review was necessary to ensure quality control and verify the accuracy of the data. This is important since there are various issues that may impact this analysis. For example, data were extracted for all crashes that occurred at the Baldwin/Coats/Indianwood roundabout in Orion Township. A comparison of data from the MSP

crash database and a manual examination of the UD-10 traffic crash form reveal that one crash designated to have occurred at this site actually occurred at a different location to the west of this roundabout. This discrepancy was due to the fact that Indianwood Road and Baldwin Road overlap, creating two unique intersections between these two roads. In addition, another crash which occurred at this location was miscoded by the investigating officer as an angle crash when it should have been coded as a rear-end collision. There were numerous such examples among the crash report forms examined as a part of this task. These types of discrepancies can lead to misidentification of crash causal factors if not correctly identified and were the primary reason for conducting a manual review as opposed to simply examining aggregate crash statistics from the crash report database.

The results of this analysis showed that during 2009, there were a total of 574 crashes involving 1,091 vehicles at the 39 roundabouts that were found to experience a crash during the calendar year as shown in Table 8. The 20 single-lane roundabouts experienced a total of 87 crashes while the 19 multi-lane roundabouts experienced a total of 487 crashes.

These data were summarized and analyzed at a disaggregate level to determine general trends and patterns common to these roundabouts. An in-depth analysis of the crash data was conducted to identify common causal factors related to various types of roundabout crashes and to determine potential emphasis areas for educational programs aimed at addressing these factors. This analysis was performed by critically reviewing the individual crash report forms (UD-10) for each location. Tables 9 and 10 provide details on the types of crashes and crash-involved drivers for both the single-lane and multi-lane roundabouts.

At the single-lane roundabouts, the most common crash types were rear-end collisions on the entry approach and sideswipe collisions between vehicles entering the roundabout and vehicles that were already circulating in the roundabout. These types of crashes were generally caused by drivers either failing to yield or yielding when it was unnecessary. Run-off-the-road and loss-of-control crashes were the next most frequent type at single-lane roundabouts and were primarily caused by drivers traveling too fast while entering the roundabout.

TABLE 8. Number of Crashes Experienced in 2009 at Michigan Roundabouts

Single-Lane Roundabouts			**Multi-Lane Roundabouts**	
Location	**Total**		**Location**	**Total**
Romeo Plank @ Cass Rd.	15		M-53 (Van Dyke) @ 18 1/2 Mile Road	122
Tienken @ Sheldon	11		W. Maple Rd @ Farmington Rd.	67
25 Mile @ Hayes	8		Lee Road @ Whitmore Lake Road	62
NB I-75 @ M-81	7		W. Maple Rd @ Drake Rd	58
M-43 @ 12th St/72nd St.	6		14 Mile Rd @ Farmington Rd.	57
Wood St. @ Sams Way	5		Romeo Plank @ 19 Mile	17
Bogie Lake Rd. @ Cooley Lake Rd.	4		Baldwin @ Indianwood/Coats Road	14
Willow Hwy @ Canal Rd.	4		Lake Lansing @ Chamberlain	11
Bennett Rd. @ Hulett Rd.	3		Bogue @ Shaw	11
Cheery Street @ Jefferson Ave.	3		Lee Road @ US 23	11
Morgan Blvd. @ Taft Rd.	3		W. Michigan Ave. @ Kalamazoo/Park/Parkview	10
Tienken @ Runyon/Washington	3		Lee Road @ Fieldcrest	10
Michigan @ Washington	3		Utica @ Dodge Park	8
Main St. @ 3rd St	2		68th Ave @ Randall	7
Cooley Lake Road @ Oxbow Lake Road	2		M-14 (east) @ Maple	7
Kensington @ Jacoby	2		M-14 (west) @ Maple	6
Old-27 @ Livingston Blvd.	2		Hamilton @ Marsh	5
SB I-75 @ M-81	2		W. Michigan @ Rankin/ Knollwood	3
Campus Pkwy @ Suncrest	1		Loop Rd. @ Commerce Crossing	1
W. Western Ave @ 3rd St.	1			
Total	**87**		**Total**	**487**

At the multi-lane locations, the entering-circulating sideswipes and rear-end crashes on the entry approaches were again quite prevalent. However, the most common type of crashes involved sideswipe collisions within the circulating lanes. These types of crashes were frequently caused by drivers changing lanes, drifting outside of designated lane, or attempting to exit from the wrong lane within the roundabout.

Among the crash-involved drivers, young drivers were overrepresented in crashes at single-lane roundabouts as shown in Table 10. These types of crashes generally involved inexperience, such as not yielding appropriately or entering the roundabout at too high of a speed. Conversely, elderly drivers were overrepresented among those crashes that occurred at multi-lane

roundabouts as they frequently had difficulty in determining appropriate gaps in circulating traffic, selecting the correct lane, and knowing how and where to exit the roundabout. The other age groups showed similar percentages of crash involvement at both the single- and multi-lane roundabout locations. When examining gender, 51.24 percent of crash-involved drivers were male and 44.64 percent were female. These percentages were relatively similar between the single-lane and multi-lane roundabouts.

TABLE 9. Crash Type by Roundabout Type

Crash Type	All		Single-Lane		Multi-Lane	
	Number	**Percentage**	**Number**	**Percentage**	**Number**	**Percentage**
Entering-Circulating (Sideswipe)	176	30.66%	23	26.44%	153	31.42%
Sideswipe in Circulating Lanes	154	26.83%	0	0.00%	154	31.62%
Rear-End on Entry Approach	107	18.64%	23	26.44%	84	17.25%
Loss-of-Control/Run-off-the-road	51	8.89%	21	24.14%	30	6.16%
Other	28	4.88%	10	11.49%	18	3.70%
Sideswipe on Entry Approach	27	4.70%	5	5.75%	22	4.52%
Rear-End in Circulating Lanes	25	4.36%	3	3.45%	22	4.52%
Exiting-Circulating (Sideswipe)	4	0.70%	2	2.30%	2	0.41%
Pedestrian	2	0.35%	0	0.00%	2	0.41%
Total	**574**	**100%**	**87**	**100%**	**487**	**100%**

In addition to the Michigan crash data, the existing research literature provided confirmed some of the Michigan findings and provided additional details on road user behaviors and actions that were found to commonly contribute to crashes at roundabouts. In 2001, Flannery highlighted the findings of a 3-year study carried out for FHWA investigating the performance of roundabouts and the effect of geometric elements on their safety and operational performance [*31*]. Flannery studied eight single lane roundabouts in Maryland and Florida including a review of the crash records at each of the locations. She found that 45 percent of crashes were a result of loss of control; 24 percent were rear end; and 27 percent were failure to yield crashes. Upon further examination of the driver crash reports, she found that two of every three sideswipe crashes were a result of driver traffic violation. These types of crashes were hypothesized to decline with greater public awareness of roundabouts and further public education as to their operation. Of the loss of control crashes, three of every five were a result of entering drivers approaching the roundabout at excessive speeds as reported to officers and included in crash reports.

Additionally, it was noted that 14 of 15 loss-of-control crashes were at rural single lane roundabouts with little to no upstream speed reduction curves to raise driver awareness as to the presence of a roundabout ahead.

TABLE 10. Age and Gender of Crash-Involved Drivers by Roundabout Type

Age of Driver	**All**		**Single-Lane**		**Multi-Lane**	
	Number	**Percentage**	**Number**	**Percentage**	**Number**	**Percentage**
<20	95	8.71%	21	13.82%	74	7.88%
20-30	184	16.87%	21	13.82%	163	17.36%
30-40	184	16.87%	28	18.42%	156	16.61%
40-50	199	18.24%	29	19.08%	170	18.10%
50-60	169	15.49%	24	15.79%	145	15.44%
>60	203	18.61%	22	14.47%	181	19.28%
Unknown	57	5.22%	7	4.61%	50	5.32%
Total	**1091**	**100.00%**	**152**	**100.00%**	**939**	**100.00%**
Gender of Driver	**All**		**Single-Lane**		**Multi-Lane**	
	Incidence	**Percentage**	**Incidence**	**Percentage**	**Incidence**	**Percentage**
Male	559	51.24%	82	53.95%	477	50.80%
Female	487	44.64%	64	42.11%	423	45.05%
Unknown	45	4.12%	6	3.95%	39	4.15%
Total	**1091**	**100.00%**	**152**	**100.00%**	**939**	**100.00%**

Flannery also discussed the effect of over-designing roundabouts for capacity. Two large roundabouts in Summerlin, Nevada were studied in the field to observe driver behavior. Both roundabouts, at the time of field observations, were operating at very low volume to capacity ratios (0.28 and 0.17). Many approach lanes and many circulating lanes (ranging between two and three lanes) were provided for few vehicles during the peak hours (850 and 1025 vph). The observations made were that drivers increased their speed on entry; cut across several lanes in the circulating roadway to maintain their speed; and several drivers made left turns at the approach heading in a clockwise direction in what appeared to be their confusion on how to negotiate the roundabouts.

A review of the final report *NCHRP 572: Roundabouts in the United States*, revealed that a total of 55 sites were included in the before/after safety study with 1159 crashes in the before period

and 726 crashes in the after period. Researchers reported the average study period in the before condition was 3.7 years and the average study period in the after period was 3.3 years. Table 11 contains a breakdown of accidents by type for the overall dataset. Note that only 39 roundabouts were able to provide approach level crash statistics resulting in 139 legs included in Table 11.

TABLE 11. Incidence of Approach Level Crashes by Type (source: NCHRP Report 572)

Crash Type	All		Single Lane		Multilane	
	Number	Percentage	Number	Percentage	Number	Percentage
Entering- Circulating (Sideswipe)	141	23%	40	29%	101	22%
Exit-Circulating (Sideswipe)	187	31%	10	7%	177	38%
Rear-End on Approach	187	31%	42	30%	145	31%
Loss of Control on Approach	77	13%	42	30%	35	7%
Pedestrian	5	1%	1	1%	4	1%
Bicyclist	8	1%	3	2%	5	1%
Sum*	**605**	**100%**	**138**	**99%**	**467**	**100%**

As is shown, at both single and multi-lane roundabouts, pedestrian and bicyclist crashes account for only 1 percent of the total crashes, while entering crashes accounted for 23 percent of overall crashes and loss of control crashes accounted for 13 percent of overall crashes. A further review of the data reveals that loss of control crashes occur more frequently at single lane approaches, a fact supported by previous work [*31*]. It is interesting to note the increase in exit-circulating crashes at multi-lane roundabouts as compared to single lane roundabouts, from 7 to 38 percent of overall crashes at the respective roundabout type. While the number of crashes reduced in the after period, the data indicate room for improvement in driver performance which may be achievable through additional education, improved geometric design, and improved signage and pavement markings.

Based on a review of both the Michigan crash data and prior studies, those road user behaviors and actions which appear to most commonly contribute to crashes at roundabouts include the following:

- Difficulty understanding rules governing yield signs and confusion about whether drivers must stop when entering roundabout when no conflicting vehicle is present
- Not being provided with enough advance warning of upcoming roundabouts
- Excessive speed while approaching and entering roundabouts

- On multilane approaches and entries to multilane roundabouts, driver confusion regarding appropriate lane selection for their desired movement
- For drivers circulating within multilane roundabouts, confusion regarding the proper lane selection for their desired movement (immediate exit or continue through roundabout to subsequent exit)
- Frequent, abrupt lane changes near multilane roundabout entries and on exit approaches
- Not recognizing or yielding to pedestrians who are about to cross the roundabout entry or exit point
- Not recognizing cyclists who are circulating in the roundabout

6.0 ROAD USER SURVEY

In addition to identifying those factors contributing to roundabout crashes, it is important to determine public feedback with respect to roundabouts. Public acceptance of roundabouts is an important concern of road agencies since opposition may potentially delay the introduction of roundabouts at locations where traffic operations and safety may be improved by such installations. Such concerns may be due to unfamiliarity or misinformation, among other reasons. To assess issues of public concern, a road user survey was developed to obtain public feedback on roundabouts. This survey solicited feedback on numerous issues, including general perceptions of roundabout operations, positive and negative experiences associated with negotiating roundabouts, and points of confusion or difficulty from a user standpoint. Prior to implementation, a draft questionnaire survey instrument was developed and submitted to MDOT for review and comment prior to dissemination. Pilot testing of the survey instrument was also done to ensure that the questions were clearly worded and understandable for the general public. The final survey form, shown in Figure 4, was approved by MDOT and implemented via Zoomerang™ [*28*].

Wayne State University Transportation Research Group
Road User Survey on Roundabout Use
http://www.michigan.gov/roundabout

The purpose of this survey is to collect information regarding public knowledge and perceptions of roundabouts. Roundabouts are a type of traffic circle used in place of traffic signals and stop signs that allow for continuous traffic flow through an intersection at low speed. This data will be used in the development of public information and education programs aimed at improving road user knowledge of roundabouts. Your participation in this effort is greatly appreciated.

1. Age: _____ 2. Gender: □Male □Female 3. County of Residence: _____

4. Indicate whether you have used any of the following modes of travel through a roundabout. (Check all that apply.)
□Automobile □Bicycle □Motorcycle □Commercial Motor Vehicle (i.e., semi) □Walking

5. Approximately how many different roundabouts have you traveled through outside of the State of Michigan?
□0 □1 to 5 □6 to 10 □more than 10

6. Approximately how many different roundabouts have you traveled through within the State of Michigan?
□0 □1 to 5 □6 to 10 □more than 10
Please list the locations of any Michigan roundabouts that you have recently traveled through: _____

_____

7. When was the last time you traveled through a roundabout?
□Today □Past Week □Past Month □Past Year □Never

8. Have you ever purposefully avoided a roundabout when traveling?
□Yes □No

9. When a vehicle is entering a roundabout, which driver is required to yield?
□ Drivers entering the roundabout □Drivers already circulating in the roundabout

10. On a scale from 1 (very uncomfortable) to 5 (very comfortable), how comfortable are you:

Selecting the proper lane prior to entering a roundabout?	□1	□2	□3	□4	□5	□Unsure
Merging into traffic/entering a roundabout?	□1	□2	□3	□4	□5	□Unsure
Circulating in a roundabout?	□1	□2	□3	□4	□5	□Unsure
Changing lanes in a roundabout?	□1	□2	□3	□4	□5	□Unsure
Exiting a roundabout?	□1	□2	□3	□4	□5	□Unsure

11. On a scale from 1 (very unsafe) to 5 (very safe), how safe do you feel roundabouts are for:

Drivers?	□1	□2	□3	□4	□5	□Unsure
Bicyclists?	□1	□2	□3	□4	□5	□Unsure
Pedestrians?	□1	□2	□3	□4	□5	□Unsure

12. Compared with stop signs and traffic lights, would you say roundabouts are:
□More safe □Less safe □About the same
Why do you feel this way? _____

13. Compared with stop signs and traffic lights, would you say roundabouts cause:
□More traffic delay □Less traffic delay □About the same
Why do you feel this way? _____

14. What is your general opinion of roundabouts compared to stop signs and traffic signals?
□Strongly oppose □Somewhat oppose □Don't know □Somewhat favor □Strongly favor

15. If a local road agency were to develop a public information and education campaign regarding roundabouts, which mode(s) of delivery would be most useful to you?
□Television □Radio □Newspaper □Internet □E-mail
□Letter/Mailing □Social Media (e.g., facebook, Twitter) □Other: _____

FIGURE 4 Road User Survey Form

In order to facilitate public response, the survey was widely advertised by MDOT through a variety of media outlets. This included the release of a media advisory, which led to coverage by television, radio, newspaper, and Internet sources. It should be noted that the purpose of this survey was to examine overall public perceptions of roundabouts and to identify common areas of concern related to roundabouts. As the survey was web-based, the sample is not necessarily representative of all Michigan road users since only users with Internet access who had learned about the survey were able to respond. A total of 11,972 survey responses were received during the implementation period in the spring and summer of 2010. The survey results are presented in Tables 12 through 16 and a discussion of these results follows.

The survey provided relatively balanced responses among all age groups, with the exception of respondents under age 20, who comprised only 2.8 percent of the sample. Males were overrepresented and made up 56.2 percent of the sample, compared to 43.3 percent females, with the remainder leaving gender unmarked. Nearly half (48.6 percent) of the survey respondents were residents of the Metro Region, followed by the University region (22.9%), with the remaining regions comprising between 1.9 and 8.3 percent of all respondents.

TABLE 12. Demographics of Survey Respondents

Age	Number	Percent	Gender	Number	Percent	Region	Number	Percent
Under 20	339	2.8%	Male	6,723	56.2%	Bay	681	5.7%
20 - 29	1,750	14.6%	Female	5,183	43.3%	Grand	988	8.3%
30 - 39	2,106	17.6%	Unknown	66	0.6%	Metro	5,821	48.6%
40 - 49	2,477	20.7%	Total	11,972	100.0%	North	230	1.9%
50 - 59	2,824	23.6%				Southwest	393	3.3%
60 - 69	1,883	15.7%				Superior	838	7.0%
Over 69	507	4.2%				University	2,736	22.9%
Unknown	86	0.7%				Other	141	1.2%
Total	11,972	100.0%				Unknown	37	0.3%
						Total	11,972	100.0%

Table 13 shows that 57.0 percent of respondents had indicated that they had purposefully avoided a roundabout on a trip on at least one occasion. While 93.6 percent of respondents correctly indicated that drivers entering the roundabout were required to yield the right-of-way to

circulating traffic, 1.7 percent were unsure and 4.7 percent answered incorrectly, indicating that there are still substantial portions of the population who are unfamiliar with roundabout operations.

TABLE 13. Experience and Knowledge of Respondents with Roundabouts

Responses to Question: Have you ever purposefully avoided a roundabout?	**Number**	**Percent**
Yes	6,823	57.0%
No	4,972	41.5%
Unknown	177	1.5%
Total	11,972	100.0%
Responses to Question: When a vehicle is entering a roundabout, which driver is required to yield?	**Number**	**Percent**
Drivers Already Circulating in the Roundabout	568	4.7%
Drivers Entering the Roundabout	11,207	93.6%
Unknown	197	1.7%
Total	11,972	100.0%

Table 14 provides details of respondent experiences with roundabouts, both in Michigan and in other areas. Overall, nearly 99 percent of all respondents had traveled through a roundabout at some point in their life. Only 3.9 percent had not traveled through a Michigan roundabout and the majority (66.3 percent) had traveled between 1 and 5. Approximately 63 percent of respondents had driven through a roundabout during the past week at the time they completed the survey, showing that a substantial portion of respondents had at least some degree of roundabout experience.

TABLE 14. Experience of Respondents with Roundabouts

Roundabouts Traveled Outside MI	**Number**	**Percent**	**Roundabouts Traveled Inside MI**	**Number**	**Percent**	**Last Time Roundabout Traveled**	**Number**	**Percent**
Zero	2,770	23.1%	Zero	462	3.9%	Never	83	0.7%
1 to 5	4,725	39.5%	1 to 5	7,939	66.3%	Past Year	1,454	12.1%
6 to 10	1,429	11.9%	6 to 10	2,422	20.2%	Past Month	2,844	23.8%
Over 10	2,871	23.9%	Over 10	1,051	8.8%	Past Week	5,161	43.1%
Unknown	177	1.5%	Unknown	98	0.8%	Today	2,361	19.7%
Total	11,972	100.0%	Total	11,972	100.0%	Unknown	69	0.6%
						Total	11,972	100.0%

Table 15 provides details of how respondents perceived the level of comfort and safety provided by roundabouts in various scenarios. The majority of drivers were either comfortable or very comfortable when selecting a lane prior to entering a roundabout, merging into traffic, circulating, and exiting the roundabout. Conversely, over 48 percent of motorists were uncomfortable with changing lanes in a roundabout. This is to be expected as drivers should not change lanes while traveling in a roundabout, though field behavioral studies and crash data revealed such behavior regularly takes place among motorists. This provides an important emphasis area for subsequent public awareness campaigns aimed at reducing the frequency of roundabout crashes.

TABLE 15. Respondent Comfort with Roundabouts

Driver Action	Level of Comfort by Driver Action (1 – very uncomfortable, 5 – very comfortable)							Total
	1	2	3	4	5	Unsure	Unknown	
Selecting the proper lane prior to entering a roundabout	2,533 (21.2%)	1,489 (12.4%)	1,483 (12.4%)	2,086 (17.4%)	4,253 (35.5%)	63 (0.5%)	65 (0.5%)	11,972 (100%)
Merging into traffic/entering a roundabout	2,868 (24%)	1,528 (12.8%)	1,392 (11.6%)	1,941 (16.2%)	4,119 (34.4%)	41 (0.3%)	83 (0.7%)	11,972 (100%)
Circulating in a roundabout	2,433 (20.3%)	1,344 (11.2%)	1,404 (11.7%)	1,980 (16.5%)	4,660 (38.9%)	41 (0.3%)	110 (0.9%)	11,972 (100%)
Changing lanes in a roundabout	4,030 (33.7%)	1,722 (14.4%)	1,556 (13%)	1,755 (14.7%)	2,641 (22.1%)	166 (1.4%)	102 (0.9%)	11,972 (100%)
Exiting a roundabout	2,246 (18.8%)	1,222 (10.2%)	1,267 (10.6%)	1,938 (16.2%)	5,121 (42.8%)	40 (0.3%)	138 (1.2%)	11,972 (100%)
Road User Group	**Perception of Safety by Road Users (1 – very unsafe, 5 – very safe)**							**Total**
	1	**2**	**3**	**4**	**5**	**Unsure**	**Unknown**	
Drivers	3,320 (27.7%)	1,715 (14.3%)	1,552 (13%)	1,918 (16%)	3,301 (27.6%)	90 (0.8%)	76 (0.6%)	11,972 (100%)
Bicyclists	5,600 (46.8%)	1,479 (12.4%)	1,463 (12.2%)	942 (7.9%)	1,023 (8.5%)	1,221 (10.2%)	244 (2.0%)	11,972 (100%)
Pedestrians	5,922 (49.5%)	1,402 (11.7%)	1,278 (10.7%)	854 (7.1%)	1,056 (8.8%)	1,210 (10.1%)	250 (2.1%)	11,972 (100%)

When asked to assess safety, responses essentially mirrored each other as 27.6 percent of respondents believed that roundabouts were very safe for drivers and 27.7 percent thought they were unsafe. Conversely, respondents felt that roundabouts were particularly unsafe for both bicyclists and pedestrians. They were judged to be very unsafe for bicyclists by 46.8 percent or respondents and very unsafe for pedestrians by 49.5 percent of respondents. Despite the fact that the crash data indicated very few pedestrian- or bicycle-involved crashes, this is likely due in

part to the low volumes of such road users at most Michigan roundabouts. Based on these results, sharing the road with other users provides an opportunity for further improving safety through educational materials.

The last series of questions, the results of which are shown in Table 16, asked respondents to compare roundabout operations, safety, and their overall preferences with traditional signalized and stop-controlled intersections. These results indicate that over half (52.7 percent) of respondents feel that roundabouts are less safe than stop signs and traffic signals. Though the research has shown that roundabouts, particularly single-lane roundabouts, provide significant improvements in safety, public perceptions are in significant contrast to this finding. As such, it is important to emphasize the benefits of eliminating conflicts points that contribute to various crash types (e.g., head-on, head-on/left-turn, angle) to help illustrate roundabout safety benefits to the traveling public. Conversely, a nearly identical number of respondents (52.7 percent) feel that roundabouts reduce delay in comparison to traditional intersection configurations. Overall, public support was largely split among respondents, with 38.9 percent strongly opposed and 30.6 percent strongly in favor. This is consistent with various previous studies in areas where roundabouts were a relative novelty as illustrated by Retting [*8, 9, 10*] and others.

Lastly, respondents were asked what type of delivery media would be most useful for subsequent public awareness materials. A diverse range of media were recommended, with 59.1 percent preferring television advertisements, followed by internet-based media, and newspaper ads.

TABLE 16. Overall View of Roundabouts

Responses to Question: Compared with stop signs and traffic lights, would you say roundabouts are:	**Number**	**Percent**
Less Safe	6,313	52.7%
About the Same	2,082	17.4%
More Safe	3,506	29.3%
Unknown	71	0.6%
Total	11,972	100.0%
Responses to Question: Compared with stop signs and traffic lights, would you say roundabouts cause:	**Number**	**Percent**
Less Traffic Delay	6,310	52.7%
About the Same	2,815	23.5%
More Traffic Delay	2,718	22.7%
Unknown	129	1.1%
Total	11,972	100.0%
Responses to Question: What is your general opinion of roundabouts compared to stop signs and traffic lights?	**Number**	**Percent**
Strongly Favor	3,658	30.6%
Slightly Favor	1,841	15.4%
Slightly Oppose	1,457	12.2%
Strongly Oppose	4,663	38.9%
Don’t Know	220	1.8%
Unknown	133	1.1%
Total	11,972	100.0%
Response to Question: Which mode(s) of delivery would be useful to you?	**Number**	**Percent**
Television	7,070	59.1%
Radio	2,560	21.4%
Newspaper	3,466	29.0%
Internet	5,114	42.7%
E-mail	2,077	17.3%
Social Media (e.g., Facebook, Twitter)	1,691	14.1%
Letter/Mailing	2,952	24.7%
Other	1,822	15.2%
Total	11,972	100.0%

The state-of-the-art literature review and road user survey provide the general conclusions listed below, which were drawn related to public perceptions of roundabouts. These findings helped to guide the subsequent development of the educational materials presented in Chapter 7.

- Many drivers and community residents are skeptical or opposed to roundabouts when they are first proposed, and throughout the planning stage.
- Drivers generally become more supportive of roundabouts after they are built, and this change in attitude generally continues in the years following construction as drivers become more familiar with roundabouts.
- Exposure increases driver familiarity, comfort, and perceived safety of roundabouts.
- Over time, there is increased – but not universal -- support for the use of roundabouts in place of traffic signals at specific intersections.
- At roundabout locations where entering drivers encounter excessive delays due to highly imbalanced traffic flow, public opinion can be quite negative.
- There is some evidence that older drivers have a greater potential for incorrect roundabout negotiation compared to younger drivers, and that certain design features can increase older driver understanding and comfort at roundabouts.
- Public support for roundabouts can be improved through consensus building and effective public information and education efforts, including workshops, public meetings, and door-to-door visits with affected businesses designed to solicit public input.

7.0 DEVELOPMENT OF EDUCATIONAL MATERIALS

The results of the state-of-the-art and state-of-the-practice reviews, crash analysis, and road user surveys provided a rich source of information that was subsequently used to develop the suite of educational materials presented in this chapter, each of which can be implemented through various media as a part of roundabout-focused public awareness programs. Based upon these findings, the following appear to be important focus areas for educational materials and public outreach efforts:

- Instruct drivers on appropriate actions when APPROACHING and ENTERING roundabouts. This should be the main focus, and cannot be overemphasized. Appropriate actions include:

- Reduce speed well in advance of the roundabout, as if preparing to stop. Drivers essentially should view the approach to a roundabout as equivalent to passing a "Be Prepared to Stop" sign.
- Watch for pedestrians and bicyclists in the entry area. Yield to pedestrians in the crosswalk.
- Watch for traffic already in the roundabout and approaching from the left. If no vehicles are present, Yield signs allow motorists to enter the roundabout without coming to a full stop (provide some basic education on Yield signs). If vehicles are present in the roundabout, drivers should stop and wait for a safe opportunity to enter.
- At multilane roundabouts, select the proper entry lane. If intending to turn right onto the intersecting street or continue straight through the intersection (as if the roundabout were not there), motorists should generally be in the RIGHT lane. If making the equivalent of a left-turn onto the intersecting street or making the equivalent of a "U" turn, motorists should be in the LEFT lane.
- Some busy roundabouts have bypass lanes that allow motorist turning right on the intersecting street to avoid going through the central portion of the roundabout. These lanes should be identified by traffic signs.

• Instruct drivers on appropriate actions when CIRCULATING through roundabouts

- Maintain a slow but steady speed through the roundabout. Typically speeds of 20 to 30 mph are appropriate within the roundabout.
- Do not change lanes within the roundabout.
- Stay in the travel lanes. Some roundabouts include a truck apron designed for use by larger vehicles that require additional room to navigate turns. Motorists should avoid driving on these areas.
- Scan ahead for the appropriate exit and prepare to exit slowly.
- If you accidentally miss your exit, continue through the roundabout until you reach the appropriate exit.

- Instruct drivers on appropriate actions when EXITING roundabouts
    - Pay close attention to signs and pavement markings indicating whether the lane you are in requires you to exit or continue through the roundabout. In some cases, lanes allow motorists the option of exiting or continuing through the roundabout.
    - Exit slowly to avoid losing control or striking traffic islands.
    - Watch for pedestrians and bicyclists in the exit area. Bicyclists may be exiting from travel lanes. Yield to pedestrians in the crosswalk.
    - Watch for other vehicles exiting the roundabout.

In response to these focus issues, a series of public awareness materials were developed aimed at educating drivers, pedestrians, bicyclists, and other road users about roundabout operations and safety. The specific materials developed as a part of this project included the seven materials listed below, which are illustrated in Figures 5 through 11h. It should be noted that Figures 11a through 11h provides storyboards in place of the actual animation videos. Additional materials provided to MDOT as a part of this project include videos from field studies conducted at various locations, in addition to these materials.

- "How to Navigate a Roundabout: General Information" Tri-Fold Brochure
- "How to Navigate a Roundabout: Sharing the Road" Tri-Fold Brochure
- "Modern Roundabouts" Poster
- "Michigan Roundabouts" Poster
- "Benefits of Roundabouts in Michigan" Poster
- "Roundabouts: Frequently Asked Questions" PowerPoint Slides
- Roundabout Animation Videos (Storyboards)