Establishing Roundabout Guidelines for a State DOT

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Abstract. With the increasing popularity of roundabouts as a traffic control option, and in the wake of the publication of FHWA's *Roundabouts: An Informational Guide*, many State and local transportation agencies are no doubt in the process of developing guidelines and policies for the use of roundabouts within their respective jurisdictions. The purpose of this paper is to explore the process used, and the issues encountered, by the Missouri Department of Transportation (MoDOT) in developing the first phase of its statewide roundabout guide.

Basic questions must be answered during the development process, such as: How can the recommendations of the FHWA manual, MUTCD, and HCM be reconciled and integrated? How can the experiences of other States and countries, as well as professional organizations such as ITE, benefit an agency developing such guidelines? What is the appropriate level of information to be contained in such a document, given that the national publications referenced above already provide a fairly comprehensive set of guidelines? What other resources exist to aid development of such a document? What is the line between essential and optional elements, for both design and planning considerations?

A key issue in the development of such a document is the policy context in which it is implemented, with associated implications that extend beyond engineering considerations - such as driver education, and legal "road rule" considerations of a currently unusual form of traffic control. This paper addresses these issues, and is intended to serve as a resource for agencies developing similar guidelines.

Why Establish Guidelines?

In the year 2000, MoDOT's first two "modern roundabouts" were opened to traffic. The first was a five-leg, one-lane roundabout located mid-state at I-70 Westbound ramps/Business I-70/Creasy Springs Road in Columbia. The second was a more standard four-leg, one-lane facility on Route 45 in Parkville (on the west side of the state, near Kansas City). With several more roundabouts at the design or concept stage, MoDOT decided that the time was right to establish a uniform set of statewide guidelines.

MoDOT's first two "modern" roundabouts.

Why would a State (or other agency) need to establish roundabout guidelines, when the recently published FHWA document (*Roundabouts: An Informational Guide*) is such a comprehensive resource? MoDOT had several answers to this question:

- FHWA's document is an "Information Guide", not a policy. MoDOT wanted a policy-level document that would define an enforceable set of requirements.

- Roundabouts were beginning to appear more often as a traffic control solution on MoDOT facilities, and the DOT wanted to ensure uniformity and consistency with respect to essential design principles. This was felt to be a key aspect not only in the safe and efficient operation of roundabouts, but also in their acceptance and understanding by the driving public.

- As a matter of procedure, MoDOT needed to address roundabouts in its *Project Development Manual (PDM)*. The manual outlines design procedures for other forms of intersection control, and the recent emergence of roundabouts in the United States merits a similar treatment.

- The approaches and philosophies of many of the available published roundabout resources – as well as those of many key roundabout advocates/practitioners – differ on certain design elements. MoDOT wanted a policy that would select the "best" elements of the various approaches and filter out conflicting stances.

- The FHWA guide, as well as other published resources, allows room for designer discretion in certain areas for which a State agency would prefer a more fixed set of requirements.

A technical committee was established within MoDOT, charged with developing statewide roundabout guidelines. The committee included key personnel from MoDOT Headquarters, personnel from the two Districts with existing roundabouts "on the ground", and representatives of HDR Engineering, Inc. (who compiled the final document).

Although MoDOT wanted to ensure uniformity, the committee recognized that flexibility on many design issues was important. Therefore, the guidelines were fashioned not as a rigid "cookbook", but rather as a set of elements that a designer must address, with mandatory items clearly delineated.

Early in the process, the committee decided that the guidelines' development would be divided into two chronological phases. The first phase, which has been completed, developed guidelines for single-lane roundabouts only. The second phase would develop guidelines for multi-lane roundabouts. The committee took this approach because multi-lane roundabouts introduce a more complicated set of issues, and it was felt that more time should be taken in resolving those issues.

Existing Resources

To understand the currently available resources, MoDOT undertook a literature search. Although not exhaustive, this research was extensive, and some of the key publications examined are briefly described below.

- As mentioned previously, FHWA's *Roundabouts: and Informational Guide* is perhaps the most comprehensive American resource on roundabouts. Covering topics from planning to operations to design, this document was an essential starting point for MoDOT.

- The Austroads publication *Guide to Traffic Engineering Practice, Part 6 - Roundabouts*, is one of the oldest standards related to "modern" roundabouts. It has provided the foundation for many American designs.

- Ourston Roundabout Engineering's *Roundabout Design Guidelines* was one of the first roundabout standards published in the United States (in 1995). It is an adaptation of the United Kingdom publication *Geometric Design of Roundabouts* (1993), another well-established roundabout reference. The document focuses largely on geometric design and layout of roundabouts.

- The Florida Department of Transportation (FDOT) publication *Florida Roundabout Guide* is one of the more lengthy and thorough State guidelines, in existence since 1996. It is an excellent and useful resource, and - among its many elements - contains a detailed justification procedure.

- The Oregon Department of Transportation (ODOT) conducted detailed research on roundabout standards in 1998. The resulting publication, *Modern Roundabouts for Oregon*, is a comprehensive summary and comparison of the publications discussed here, as well as many others. Based on the findings of this document, ODOT has subsequently developed guidelines for single-lane roundabouts.

Justification Procedures

One of the most important design decisions related to roundabouts is made long before design begins: is a roundabout the appropriate form of control for a given location? FDOT's manual includes a fairly detailed justification procedure that can serve as an excellent starting point for agencies attempting to create such procedures. Other agencies have treated the justification process with varying levels of depth.

MoDOT wanted to ensure that a thoughtful, rigorous analytical process would accompany the decision to install any roundabout on a State facility. To this end, the committee debated the best way to establish justification procedures that could quickly "screen out" locations at which roundabouts would be obviously inadvisable, with a refined approach to further analyze locations that survived the "first filter". The committee devised a checklist divided into three sections, as shown on the following page.

Conditions under which roundabouts *may be appropriate*	- Intersections warranting safety improvements (crash rate/severity, visibility, movement separation) - Intersections with design-year entering peak-hour volumes typically not exceeding 2,400 to 2,800 vehicles - Intersections with unusual geometrics - As an alternative to a low- or medium-volume signal - As an alternative to all-way stop control - Intersections with high side-street delays - Intersections at which signal warrants are not met but delay problems still exist - Intersections with high left- or U-turn volumes - Intersections with five or more legs - Locations with right-of-way limitations on approaches - Locations at which road character changes (i.e. 55 to 35 mph, rural to urban, divided to undivided)
Conditions under which roundabouts *may NOT be appropriate*	- Intersections with design-year entering peak-hour volumes exceeding 2,400 to 2,800 vehicles - Locations with grades exceeding 3% or topography that might limit visibility, complicate construction or create unsafe conditions - Locations with right-of-way limitations at the intersection - Roadways on which a lack of large gaps caused by signal-related platooning could cause undesirable effects up/downstream of a roundabout - Intersections with unbalanced traffic, where major street traffic might be unduly delayed - Locations with heavy pedestrian or bicycle movements; pedestrian special need areas - Locations near emergency facilities (such as hospitals or fire stations) that could be negatively impacted by the inability to preempt traffic - Locations with nearby generators of significant traffic that might have trouble negotiating the roundabout (e.g. high volumes of large trucks)
Conditions under which roundabouts *WILL NOT be used*	- Locations with physical/geometric complications that make it impossible/uneconomical to construct a roundabout - Routes where large vehicles will frequently use the intersection and sufficient space is unavailable - Locations with nearby traffic control devices requiring preemption (railroad tracks, drawbridges) - Locations with nearby bottlenecks that would routinely back up into the roundabout (overcapacity signals, freeway entrance ramps) - Isolated intersections within a coordinated network - Roadways with reversible lanes

MoDOT's checklist of "Potentially Appropriate and Inappropriate Sites for Roundabouts".

Once a potential roundabout survives this "first filter", MoDOT's guidelines then specify the analysis tools that should be used to determine the operational feasibility of a potential roundabout, as described below.

Analytical Methods and Software

From a simplified perspective, there have traditionally been two approaches to roundabout operational analysis. For the purposes of this paper, these approaches will be called the "Australian/Gap-Acceptance" and "British/Geometric" methods. The Australian method, most frequently applied using the aaSIDRA software, is fundamentally based on a gap-acceptance model, secondarily influenced by certain geometric parameters. The British method, which has been incorporated into software packages such as ARCADY and RODEL, employs an empirical capacity model based on numerous geometric parameters. The relative merits of these two methods have been the subject of intense debate among roundabout practitioners, and it does not fall within the scope of this paper to add to this debate.

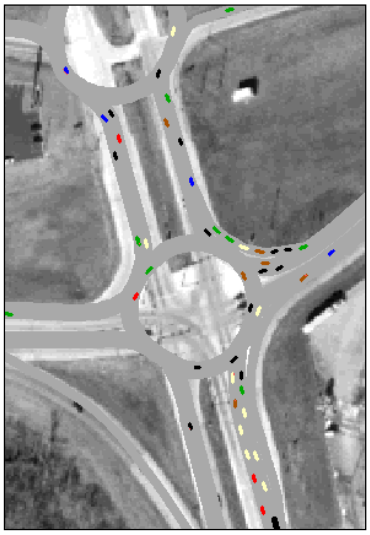
Complicating matters for American roundabout practitioners, the 2000 Highway Capacity Manual (HCM) introduced an "American" methodology for roundabout analysis. The methodology is based on gap-acceptance principles, but - by the HCM's own admission – it is

still in its infancy: "… a comprehensive methodology for all situations cannot be offered." Data on American roundabouts is still limited; therefore, the HCM method is only applicable to single-lane roundabouts with circulating flows of less than 1,200 vehicles per hour.

After much discussion, the committee decided that an initial check of roundabout capacity should be made using HCM procedures, but that aaSIDRA would be the required software for detailed operational analysis. The SIDRA software's increasing prevalence of use in the United States, and the committee's comfort level with a gap-acceptance-based analysis approach, were key factors in this decision. The committee recognized that roundabout analysis (especially in the United States) is a rapidly evolving discipline, and that available software (and methodologies) will inevitably change. However, MoDOT's PDM is updated quarterly, and therefore it will be relatively easy to "change with the times". It was considered very important to require uniformity of software so that reviewers at the District and Headquarters levels can have consistent expectations.

The committee decided that the guidelines should also echo the popular concept of "practical capacity" for roundabouts, including a statement in the guidelines that "roundabouts should be designed to operate at no more than 85 percent of capacity."

The committee also recognized microsimulation as a valuable tool in roundabout analysis, as well as demonstrating roundabout operations to the public. Again, in the interest of consistency and uniformity, the committee recommended a single package – VISSIM – for use in simulation. Of the moderately priced simulation software packages currently available, VISSIM is the best suited for representing roundabouts.



VISSIM simulation of a potential roundabout.

Key Design Elements

The bulk of MoDOT's guideline document is devoted to design elements. As mentioned above, the committee felt the document's most important task was to comprehensively define all the elements that a designer should consider, while avoiding prescribing a "one size fits all", overly detailed "cookbook". Some of the key items addressed are discussed below.

- *Fundamental design principles:* the committee adopted the notion of three fundamental considerations in roundabout design: *design speed, capacity* and *design vehicle*. Accordingly, these three topics were among the first addressed in the manual. Sight distance was also recognized as a key ingredient in roundabout safety.

- *Key roundabout dimensions:* The guidelines address the dimensions of the primary features of a roundabout, including the central island, truck apron, circulatory roadway, splitter islands, and approach legs. In most cases, these dimensions were based on FHWA standards or other available standards. In some cases, modifications were made to reflect MoDOT's standards for intersection design.

One addition to the guidelines is notable in that the committee had not seen a similar standard in any of the publications reviewed: "leg separation". This concept, which arose out of the committee's experience and observations at existing roundabouts, specifies (as its name implies) a minimum distance (measured along the circulatory roadway) between adjacent legs to promote smooth traffic flow.

- Other geometric considerations: The committee included a brief section entitled "Grades, Cross-slopes, and Superelevation" giving roundabout-specific guidance on these topics. In general, these topics are covered elsewhere in MoDOT's *Project Development Manual*.

- Signing and Pavement Marking: As these are areas in which the most variability (and perhaps controversy) exists throughout the available literature and agency standards, the committee decided to be very explicit in its recommendations. The committee examined the various standards and practices, and selected what were felt to be the most appropriate for Missouri drivers (while maintaining conformity with applicable national design standards).

Final Product

MoDOT's document contains 5 pages of text, divided into 17 sections:

1. Introduction and Definitions
2. Justification Procedures
3. Operational/Capacity Analysis
4. Fundamental Design Principles
5. Design Speeds
6. Design Vehicle
7. Sight Distance
8. Central Island
9. Truck Apron
10. Circulatory Roadway
11. Splitter Islands
12. Approach Legs
13. Grades, Cross-Slopes, Superelevation
14. Bicyclists and Pedestrians
15. Signing and Pavement Marking
16. Landscaping, Lighting and Drainage
17. Traffic Control During Construction

The document also contains 8 figures:

1. Roundabout Terminology
2. Potentially Appropriate and Inappropriate Sites for Roundabouts
3. Typical Roundabout Dimensions
4. Computation of Roundabout Design Speeds
5. Sight Distance Measurements
6. Leg Separation and Typical Cross-Section
7. Potential Bicycle Lane Treatments
8. Typical Roundabout Signing and Pavement Marking

The first phase of the roundabout guidelines was incorporated into MoDOT's *Project Development Manual* (PDM) at the beginning of 2002. The justification procedures have already been used for several potential roundabout locations, and have proven to be a useful tool.

Next Steps for MoDOT

As mentioned above, MoDOT's guidelines currently only cover one-lane roundabouts. Any multi-lane roundabout designed on a MoDOT facility currently requires a Design Exception, meaning MoDOT will examine each application on a case-by-case basis. MoDOT is currently developing the second phase of its guidelines, which will address multi-lane roundabouts.

Perhaps the most important factor determining the success of roundabouts over the next few years (in Missouri and throughout the United States) will be public education. MoDOT plans to incorporate information on roundabouts into an upcoming edition of the *Missouri Driver's Manual*. MoDOT has also produced a brochure and video on roundabouts, specifically designed to educate the public on these matters.

Conclusion

Roundabout designers are fortunate to have an ever-increasing wealth of resources at their disposal. For those attempting to craft standards for their agencies, MoDOT's experiences provide a potential blueprint for a successful approach.

For further information, or for a copy of the MoDOT guidelines, contact Sam Masters, P.E. (MoDOT) at (573) 751-0909 or access the *Project Development Manual* at: http://www.modot.state.mo.us/design/p pdm/ppdm.htm.

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